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FUSIFORM RUST INCIDENCE SURVEY 1971-73

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

SOUTHEASTERN AREA

STATE AND PRIVATE FORESTRY

in cooperation with
the State Forestry Organizations

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FUSIFORM RUST INCIDENCE SURVEY 1971-1973

ACKNOWLEDGEMENT AND DEDICATION

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This report is dedicated to Elmer R. Roth who devoted 34 years of his life as a forest pathologist for the Southeastern Forest Experiment Station and the Southeastern Area, State and Private Forestry, U.S. Forest Service. He helped develop the survey method used in these surveys and helped initiate the first state-wide surveys made.

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FUSIFORM RUST INCIDENCE SURVEY 1971-73

William R. Phelps [1/]

ABSTRACT

Fusiform rust incidence surveys were cooperatively conducted by U.S. Forest Service and State forestry organizations in Alabama, Arkansas, Georgia, Florida, Louisiana, Mississippi, North Carolina, and South Carolina during the period 1971-1973. Plantations of slash and/or loblolly were sampled in the 8 to 12 year age class located at or near the intersection of grid lines that were at 10 mile east-west and north-south intervals. The ratio estimation statistical survey method was used. Maps and summary tables showing infection incidence and impact were prepared from field data.

A total of 1,319 loblolly and 1,173 slash plantations in the southeast were surveyed. Fusiform rust incidence appeared to be the highest in Georgia, Alabama, South Carolina, and Mississippi for both loblolly and slash pine. Louisiana showed a low incidence for loblolly and a high incidence for slash. Incidence was lowest in Arkansas, North Carolina, and Florida when compared to these other states. Losses due to non-merchantable and dead trees were the highest for loblolly in Alabama (4 percent) and slash in South Carolina (9 percent). All sampled trees in both species had less than 50 percent stem cankers in all the states surveyed. The highest percentage of stem cankers was found on slash pine (41 percent) and loblolly pine (31 percent) in Georgia. Rust incidence was more severe on slash than on loblolly pines. This survey showed much higher rust incidence and a wider intensified distribution than was found in the southwide survey made 35 years ago.

1/ Area Staff Pathologist, State and Private Forestry, Southeastern Area, U.S. Forest Service.

INTRODUCTION

Southern fusiform rust caused by Cronartium fusiforme Hedge and Hunt, is widely distributed from Maryland to Florida, Texas and southeast Arkansas. This disease is especially serious on slash and loblolly pines while it occurs on longleaf, pond and 23 other species and varieties of native and exotic pines. It is especially serious in slash and loblolly nursery seedlings unless intensive fungicidal suppression methods are undertaken. According to the 1952 Timber Resources Review, fusiform rust of southern pine causes an estimated annual loss of 281 million board feet of sawtimber and 97 million cubic feet of growing stock. This amounted to an annual stumpage loss of $10 million and $250 million in finished wood products. These figures are higher with increased prices of sawtimber and roundwood products in today's markets.

Fusiform rust was found very rarely before 1900. Siggers and Landgren (1947) stated that in the early thirties, trunk and branch cankers on southern pines were of interest mostly to classifiers of tree diseases. They observed that fusiform rust had increased in the Gulf South in the past 35 years. Czabator (1971) in his review paper gives some data on rust incidence by early workers.

No attempt has been made to make a southwide rust survey since Lamb and Sleeth in 1938-39 (Lamb and Sleeth 1940). Plantations, natural reproduction and forest tree nurseries were surveyed. They found rust to be most severe in the southern part of Mississippi and Alabama and southeast Louisiana, medium severity in southern Georgia and South Carolina and northern Florida. Light infection was observed in areas west of the Mississippi River and the northern parts of the Gulf and South Atlantic states including most of Florida. Schmidt, Goddard, and Hollis (1973) have just completed a rust incidence analyses of 1,286 forest industry slash pine plantations 4-21 years in Florida and south Georgia. They found an average rust incidence rate was 20.6 percent for Florida and 38.3 percent for Georgia. By the use of a regression equation using age and year of planting, they determined that rust increases to a maximum between ages 10 and 11 years and thereafter declines. Goggans (1957) surveyed the coastal plain of Alabama for rust incidence in slash, loblolly, and longleaf pine. The average age of the trees was 11 years. He found 44 percent infection in slash, 39 percent for loblolly and 16 percent for longleaf. Mason and Griffin (1970) evaluated the severity of fusiform rust in east Texas pine plantations. They found infection occurring in 98 percent of

INCIDENCE OF FUSIFORM RUST IN 8-12 YEAR LOBLOLLY PINE PLANTATIONS 1971-73

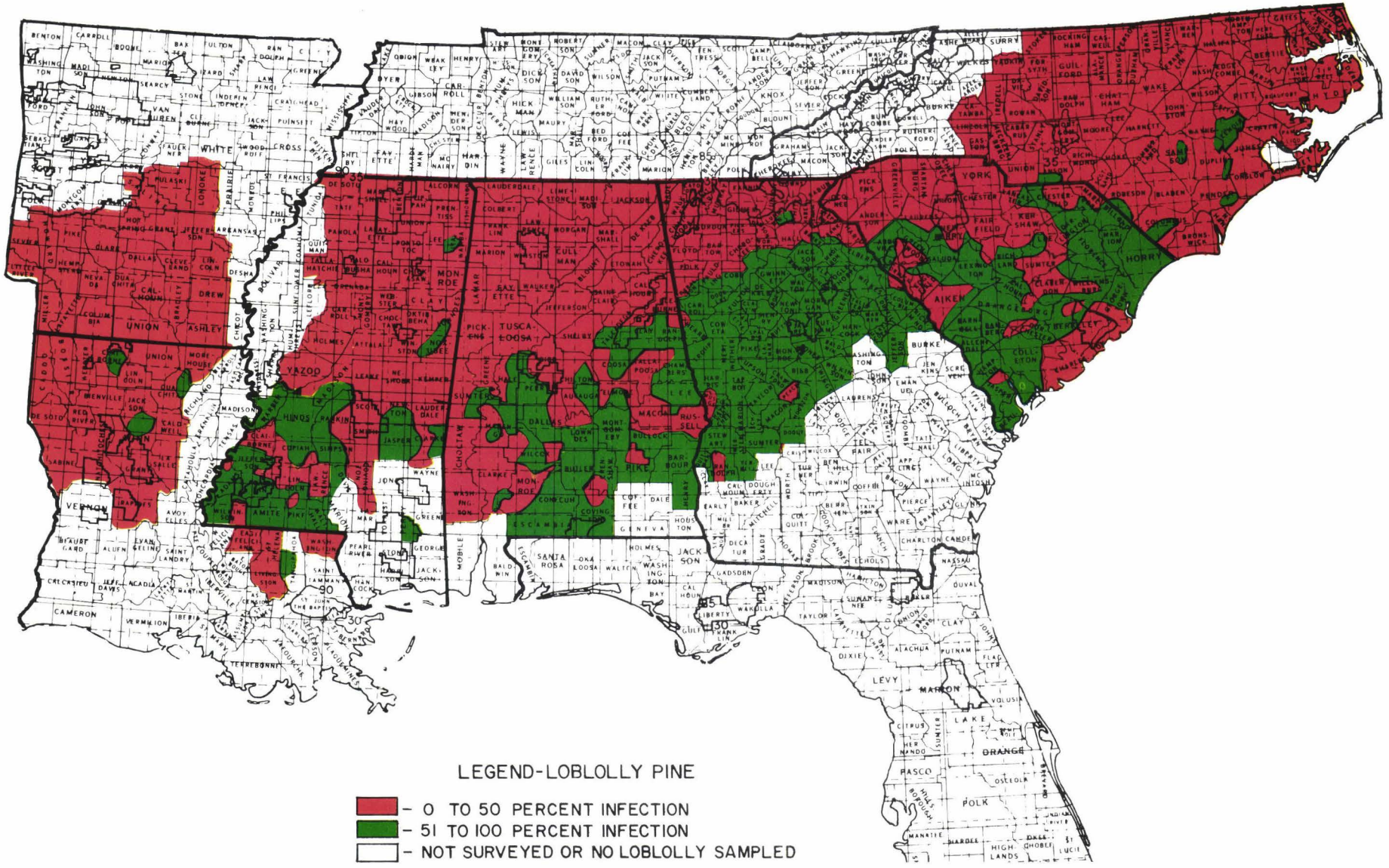

FIGURE 1

INCIDENCE OF FUSIFORM RUST IN 8-12 YEAR SLASH PINE PLANTATIONS 1971-73

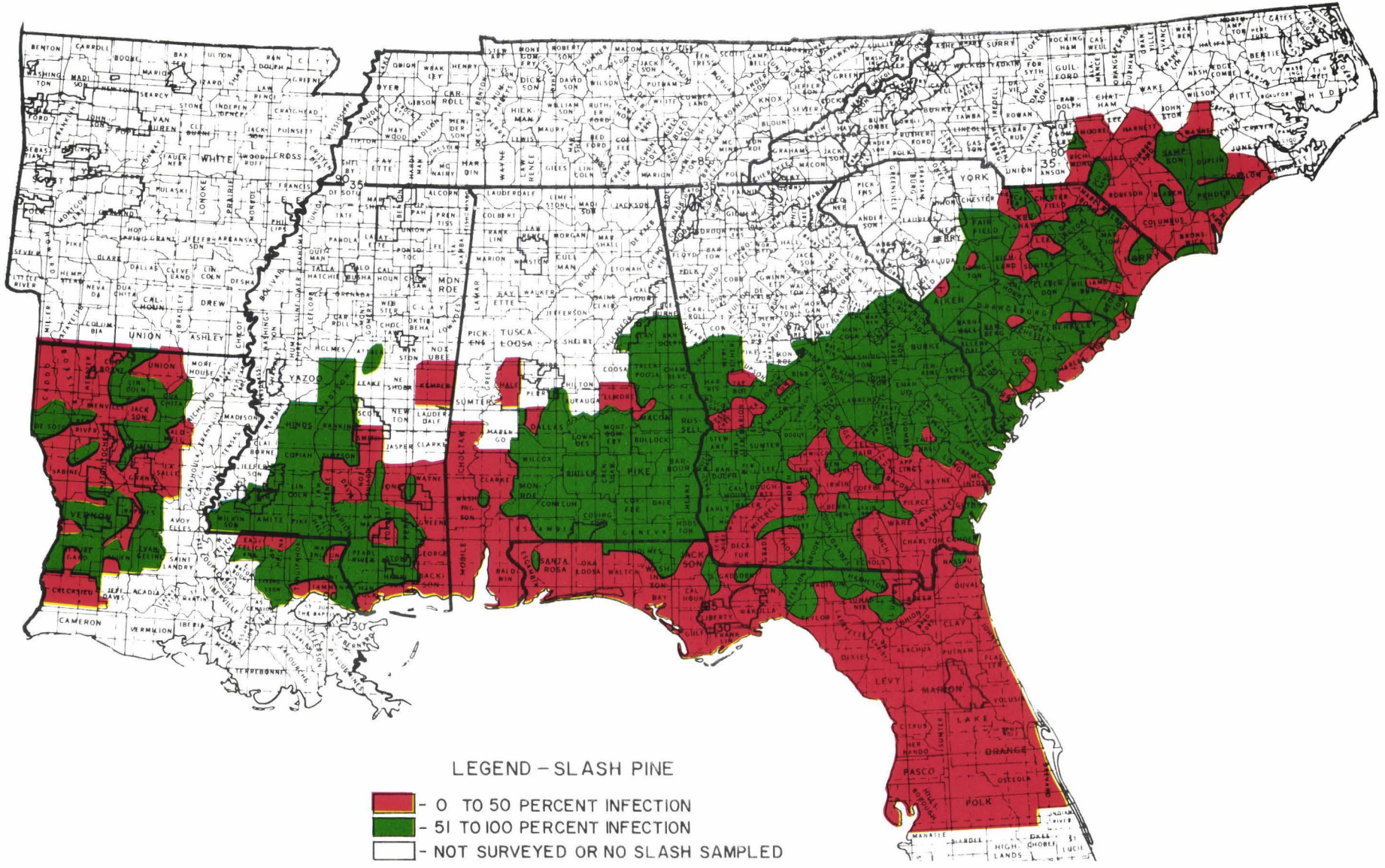

FIGURE 2

the plantations surveyed with the heaviest infection occurring in southeast Texas. Average infection rates were 8 percent for slash and 5 percent for loblolly pines. Overall rust infection was found to be creating a negligible economic impact on pines in east Texas. Artman (1969) surveyed 3 to 10 year old loblolly pine in coastal Virginia. He found 3 percent of the trees infected and in no plantation was the disease of real concern.

A southwide fusiform rust incidence survey was conducted by the U.S. Forest Service, State and Private Forestry in cooperation with the state forestry organizations of Alabama, Arkansas, Georgia, Florida, Louisiana, Mississippi, North Carolina, and South Carolina during the period 1971-73. (Phelps et.al. 1973, Roth and Tiner 1972, Roth and McComb 1972, Roth and Chellman 1971, Roth and Nachod 1971, Roth and Echols 1972, Phelps and Doggett 1973, Roth and Graham 1971). Individual state survey reports with rust incidence maps are included with this report as appendices. Figure 1 (loblolly) and Figure 2 (slash) show the incidence of fusiform rust in 8-12 year plantations in the southeast. Fusiform rust appeared to be most serious in Georgia, Alabama, South Carolina, and Mississippi especially in a corridor running northeast and southwest through the central and southern section of the states. Louisiana showed a low incidence for loblolly and a high incidence for slash. It was least severe in Arkansas, North Carolina, and Florida when compared to the other states surveyed. There was more rust infection in slash pine than in loblolly in all the states surveyed. Losses (non-merchantable and dead trees) due to the rust in the 8-12 year age class were the most severe for loblolly pine in Alabama (4 percent) and for slash pine in South Carolina (9 percent). The highest percentage of stem cankers were found on slash pine (41 percent) and loblolly pine (31 percent) in Georgia. The average age of all the slash pines sampled was 11 years, the diameter breast height (dbh) was 5.5 inches and the height was 30 feet. The average age of all the loblolly pines sampled was 11 years, the diameter breast height (dbh) was 5.8 inches and the height was 31 feet.

The percentages of healthy, stem cankered, branch cankered, and non-merchantable fusiform rust killed trees for each individual state are presented in Tables 1 to 8. Table 9 gives a summary for all the southeastern states surveyed. The tree percent is more than 100 because of the combination of infection categories. Although it appears that fusiform rust is not causing severe losses in the 8-12 year old age group for a whole state, losses in other age groups may well exceed those found in this survey. In addition, losses may be severe in local areas. Future state rust impact surveys should give further detailed age class and volume loss data.

METHODS

A survey using the Yandle-Roth ratio estimation method (Yandle and Roth 1971) was conducted in 8 of the southeastern states. All counties in a state were surveyed except where there were no loblolly or slash plantations or if there were no plantations in the 8 to 12 year age class. The entire state was grided on general highway county maps, scale 1 inch to the mile, using 10 mile square grids with lines running north-south and east-west. A plantation in the correct age group (8 to 12 years) was selected for sampling where the north-south, east-west lines intersected or were within 5 miles from the intersection point. One slash and one loblolly plantation were sampled if available in the correct age group. Plantations of less than 5 acres in area and those that had been previously pruned or thinned were not considered. In general, loblolly had a wider planting range than slash.

After selecting the plantation to be sampled, the rows were quickly counted and the 3 rows to be sampled were chosen by using a table of random numbers. The selected rows were then sampled tree by tree, recording whether trees were healthy, had a stem canker, had a branch canker, had both a branch and stem canker, had been killed by rust, or non-merchantable due to rust. A copy of the brochure entitled "Survey Procedure for Fusiform Rust" is included in this report. After the data were recorded for each county by state forestry personnel it was summarized and analyzed by personnel of State and Private Forestry, Southeastern Area. The analysis consisted of determining the percentage healthy, stem cankered, branch cankered, and dead and non-merchantable due to rust. Using these percentages, maps were developed for both loblolly and slash pine, showing areas of rust incidence as 0 to 25 percent, 26 to 50 percent, 51 to 75 percent, and 76 percent plus. Most of the states completed the field work phase of the survey in 3 months after its initiation. The surveys were generally completed without unduly interfering with the normal work load of the state organization.

RESULTS

Alabama - A total of 42,475 loblolly pine in 180 plantations and and 21,522 slash pine in 86 plantations were used in the sample. The average tree age was 11 years, the diameter breast height was 5.4 inches for both slash and loblolly pines. The tree height was 30 feet for slash and 28 feet for loblolly. Rust incidence was

especially serious in the central and southern sections of the state. In Alabama, 60 percent of the loblolly and 46 percent of the slash pines were healthy. Stem cankers were found on 19 percent of the loblolly and on 29 percent of the slash. Dead and non-merchantable trees due to rust were 4 percent for loblolly and 7 percent for slash. The range of infection was from 0 to 93 percent for loblolly and from 2 to 94 percent for slash. Table 1 gives a detailed summary of rust incidence and impact in Alabama. Appendix 1 presents the complete state rust survey report.

Arkansas - A total of 22,843 loblolly pine in 106 plantations was used in the sample. The average age of the trees was 11 years, the diameter breast height was 6.4 inches and the tree height was 34 feet. Only the southern counties were surveyed since this was the only part of the state where rust was thought to be a problem. There was very little infection and less than 1 percent dead and non-merchantable trees due to rust was found. In Arkansas, 90 percent of the loblolly was healthy. Stem cankers were found on only 3 percent of the trees. The range of infection was from 0 to 44 percent. Table 2 gives a detailed summary of rust incidence and impact in Arkansas. Appendix 2 presents the complete state rust survey report.

Georgia - A total of 52,408 loblolly pine in 182 plantations and 86,404 slash pine in 349 plantations were used in the sample. The average age of the trees was 11 years. The diameter breast height was 6.1 inches and tree height was 32 feet for slash. The diameter breast height was 6.2 inches and tree height was 30 feet for loblolly. Rust incidence is especially serious in the central and north central sections for loblolly and the central and southern sections for slash. In Georgia, 45 percent of the loblolly and 39 percent of the slash were healthy. Stem cankers were found on 31 percent of the loblolly and 41 percent of the slash. Dead and non-merchantable trees due to rust was 3 percent for loblolly and 5 percent for slash. The range of infection was from 3 to 100 percent for loblolly and from 5 to 93 percent for slash. Table 3 gives a detailed summary of rust incidence and impact in Georgia. Appendix 3 presents the complete state rust survey report.

Florida - A total of 85,206 slash pine in 286 plantations was used in the sample. Loblolly pine was not sampled because of the small number of plantations in the 8-12 year age class. The average age of the trees was 9 years, the diameter breast height was 5.3 inches and tree height was 30 feet. Rust incidence in the state is low when compared to the other southeastern states surveyed except for

parts of the most northern counties. In Florida, 83 percent of the trees were healthy. Stem cankers were found on 10 percent of the trees. Dead and non-merchantable trees due to rust was only 2 percent. The range of infection was from 0 to 94 percent. Table 4 gives a detailed summary of rust incidence and impact. Appendix 4 presents the complete state rust survey report.

Louisiana - A total of 28,107 loblolly pine in 115 plantations and 35,831 slash pine in 126 plantations were used in the sample. The average age of the trees was 11 years and diameter breast height was 5.5 inches for both species. The tree height was 31 feet for slash and 34 feet for loblolly. There is a low incidence of rust in loblolly while a high incidence is found for slash in scattered pockets throughout the state. There was considerably more infection in slash than in loblolly. In Louisiana, 72 percent of the loblolly and 48 percent of the slash were healthy. Stem cankers were found on 12 percent of the loblolly and 25 percent of the slash. Dead and non-merchantable trees due to rust was 2 percent for loblolly and 5 percent for slash. The range of infection was from 2 to 67 percent for loblolly and from 4 to 87 percent for slash. Table 5 gives a detailed summary of rust incidence and impact. Appendix 5 presents the complete state rust survey report.

Mississippi - A total of 51,560 loblolly pine in 248 plantations and and 18,548 slash pine in 71 plantations were used in the sample. The average age of both species was 11 years. The average diameter breast height was 5.5 inches for slash and 5.8 inches for loblolly. The average tree height was 29 feet for slash and 30 feet for loblolly. Rust incidence was especially high in the southwest and east central sections of the state. Rust incidence was higher in slash than in loblolly pine. In Mississippi, 67 percent of the loblolly and 53 percent of the slash were healthy. Stem cankers were found on 13 percent of the loblolly and 21 percent of the slash. Dead and non-merchantable trees due to rust was 3 percent for loblolly and 7 percent for slash. The range of infection was from 0 to 85 percent for loblolly and from 6 to 85 percent for slash. Table 6 gives a detailed summary of rust incidence and impact. Appendix 6 presents the complete state rust survey reports.

North Carolina - A total of 61,362 loblolly pine in 282 plantations and 15,940 slash pine in 76 plantations were used in the sample. The average tree age was 11 years for loblolly and 10 years for slash. The average diameter breast height was 5.1 inches for loblolly and 4.4 inches for slash. The average tree height was 26 feet for loblolly and 24 feet for slash. Rust incidence was low

in general throughout the state except the south central and southeastern sections. In North Carolina, 79 percent of the loblolly and 65 percent of the slash were healthy. Stem cankers were found on 9 percent of the loblolly and 16 percent of the slash. Dead and non-merchantable trees due to rust was 2 percent for both species. The range of infection was from 0 to 81 percent for loblolly and 5 to 72 percent for slash. Table 7 gives a detailed summary of rust incidence and impact. Appendix 7 presents the complete state rust survey report.

South Carolina - A total of 50,683 loblolly pine in 206 plantations and 46,162 slash pine in 179 plantations were used in the sample. The average age for both species was 11 years. The average diameter breast height was 6.5 inches and the average tree height was 35 feet for both species. Rust incidence was the highest for both species in the central and southern sections of the state. In South Carolina, 64 percent of the loblolly and 38 percent of the slash were healthy. There was more rust infection in slash than in loblolly pine. Stem cankers were found on 22 percent of the loblolly and 38 percent of the slash. Dead and non-merchantable trees due to rust was 3 percent for loblolly and 9 percent for slash. The range of infection was from 1 to 95 percent for loblolly and 16 to 93 percent for slash. Table 8 gives a detailed summary of rust incidence and impact. Appendix 8 presents the complete state survey report.

DISCUSSION

The purpose for conducting the statewide systematic incidence rust surveys was to develop information for tree improvement foresters and land managers on the incidence of rust in the states where loblolly and slash pine are planted. In addition, accurate estimates of rust impact are not available, and cannot be obtained until the incidence and distribution of the disease are well characterized. Foresters and land managers would like to know the rust incidence zones, so they will know where to plant rust resistant stock now being developed by their tree improvement programs and where to plant susceptible stock and still be able to produce a merchantable timber and wood products crop. The Forest Pest Management pathologists were not able to conduct systematic rust surveys until a statistically sound sampling method was developed to obtain valid data. This was done by Yandle and Roth (1971) who developed a sampling method based on ratio estimation. This method could (1) determine the intensity of infection in established

plantations and natural areas so that the land manager could make a decision as to future management of the stand, (2) to define rust incidence zones so the land manager would know where to plant resistant and susceptible planting stock, and (3) to determine where the land manager should use current silvicultural suppression measures for controlling the rust in certain areas.

The incidence of rust varies over a wide range from nil to severe over the habitat of Cronartium fusiforme in the various southeastern states. There were some large differences in the survey made by Lamb and Sleeth in 1938-39 and the current Forest Service Cooperative State surveys just completed. These differences were mainly increased rust incidence and intensity and a dissimilar distribution over the whole southeastern United States. This is possibly due to the increased number of plantation trees, especially slash pine; off site planting of the host pines; ie., planting slash pine on loblolly and longleaf pine sites, planting slash pine outside its natural range; site preparation; micro-climatic conditions on individual trees; genetic susceptibility of the pines; genetic variation (physiologic races) which may exist in the rust itself; and phenological variations in both the oak and pine hosts. The incidence and distribution of rust are similar to those reported for Florida and Georgia by Schmidt et.al., 1973.

The statement has been made that management foresters are of the opinion "that pine stands with 50 percent or less rust stem infection can be successfully managed for pulpwood, lumber, and pole products." State forestry organizations and the National Forest System were asked to comment on this statement. The Alabama Forestry Commission stated "That planted pine stands with 50 percent or less infection with fusiform rust stem cankers can be successfully managed for pulpwood, lumber, and pole products. We feel that 50 percent of the trees will be thinned out of planted stands in the first or second cutting leaving non-infected trees for the longer rotations." The Mississippi Forestry Commission commented "Up until the present time, loblolly and slash pine stands having 50 percent or less trees infected up to the age of 20 years could certainly be successfully managed for pulpwood, pole products or sawtimber. As the stands increase in age, the percentage of infected trees should be less for successful timber management." The South Carolina Forestry Commission stated "Usually there is much less impact on production than the total infection percentages indicate. A significant part of the infected trees would have no main stem cankers and no limb cankers close enough to the main stem to interfere with production. Therefore,

many stands over 50 percent total infection could be managed to pulpwood, lumber, and pole products. So a figure lower than 50 percent does not seem justified. As fusiform resistant stock becomes available we are likely to assign first priority to areas where infection rates are above 75 percent, second priority to areas where infection rates are 51-75 percent." The Georgia Forestry Commission said "It is our opinion that generally the 50 percent figure is valid with some reservations. We feel that this percentage adapts itself to pulpwood rotation more so than lumber and pole products. In slash pine plantations, the percent of dominant or co-dominant trees infected along with the initial stocking would have to be considered. An adequate or successful stand would not usually result if the majority of trees left in a slash pine plantation are the suppressed or intermediate trees." The Louisiana Forestry Commission indicated "we feel that 50 percent or less infection is something that we can live with and still manage successfully." The Florida Forest Service said "We feel that a 50 percent or less infection in a stand can be successfully managed for all products in most cases. The most important limiting factor of successful management would be the distribution of the remaining non-infected trees on each acre. This condition could make the statement invalid on a large area with scattered heavy and light infections. Another factor that could influence this statement is the number of trees originally planted. There seems to be a trend to widen spacings resulting in fewer trees per acre." A spokesman for the National Forest System said "The statement that pine stands with 50 percent or less infection with fusiform rust can be successfully managed for pulpwood, lumber, and pole products is essentially correct. However, in the case of pulpwood grown on a short rotation (25-30 years) the manager must be able to accept a fairly substantial loss of cubic foot volume if no thinning was done. Where timber is managed on a longer rotation (60 to 80 years) for production of sawlogs a higher fusiform infection might be accepted. This would be possible where timely thinnings are made and diseased trees removed so that the final crop of 30 to 60 trees per acre might be essentially disease free."

The land manager should carefully evaluate planting practices where fusiform rust is moderate to high. He can use silvicultural suppression techniques to reduce pine infection from fusiform rust. These would include (1) planting genetically resistant seedlings in the highest incidence rust zones (more than 50 percent infection as shown by the incidence survey), (2) planting alternative species such as longleaf, shortleaf, Virginia, and white pine, (3) planting more loblolly and longleaf pine and reduce slash pine planting, (4) planting pine species on site, and (5) planting higher numbers of seedlings per acre.

Districts and Counties of the Alabama Forestry Commission Surveyed for Fusiform Rust

District 1

Colbert
Etowah
Franklin
Lauderdale
Limestone
Madison
Marshall
Morgan

District 2

Cullman
St. Clair
Winston

District 3

Fayette
Hale
Pickens
Sumter
Tuscaloosa

District 4

Chambers
Clay
Cleburne
Coosa
Elmore
Lee
Randolph
Talladega
Tallapoosa

District 5

Autauga
Chilton
Dallas
Lowndes
Morengo
Montgomery
Perry
Wilcox

District 6

Barbour
Bullock
Coffee
Henry
Macon
Pike
Russell

District 7

Butler
Conecuh
Covington
Crenshaw
Escambia
Monroe

District 8

Baldwin
Choctow
Clarke
Mobile
Washington

TABLE 1. Impact of Fusiform Rust on 8-12 Year Loblolly and Slash Pine Plantations in Alabama

District	LOBLOLLY (Percent of trees)*				SLASH (Percent of trees)*			
	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead
1	84	4	9	1	--	--	--	--
2	85	3	8	2	--	--	--	--
3	77	10	14	1	52	31	25	1
4	50	20	39	2	46	29	34	5
5	47	24	33	8	42	25	36	10
6	29	39	50	11	24	38	47	17
7	33	39	46	7	32	40	46	8
8	71	13	15	2	82	10	10	1
State Average	60	19	27	4	46	29	33	7

*Percent of trees do not add up to 100 percent because of category combinations.

Districts and Counties of the Arkansas Forestry Commission Surveyed for Fusiform Rust

District 1

Lincoln
Ashley
Drew

District 2

Howard
Pike
Hempstead
Polk
Sevier
Little River

District 3

Ouachita
Calhoun
Bradley

District 5

Hot Springs
Clark
Dallas

District 7

Grant
Jefferson
Cleveland
Saline

District 8

Union
Columbia

District 9

Nevada
LaFayette
Miller

TABLE 2. Impact of Fusiform Rust on 8-12 Year Loblolly Pine Plantations in Southern Arkansas

LOBLOLLY
(Percent of trees)*

District	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead
1	89	6	11	1
2	94	1	5	0
3	82	6	15	0
4	--	--	--	--
5	92	2	7	0
6	--	--	--	--
7	92	1	7	0
8	91	2	8	0
9	92	3	6	0
State Average	90	3	8	0

*Percent of trees do not add up to 100 percent because of category combinations.

Districts and Counties of the Georgia Forestry Commission Surveyed for Fusiform Rust

District 1

Bryan
Bullock
Burke
Candler
Chatham
Effingham
Emanuel
Evans
Jenkins
Liberty
Long
McIntosh
Screven
Tattnall

District 2

Baker
Brooks
Calhoun
Clay
Colquitt
Decatur
Dougherty
Early
Grady
Miller
Mitchell
Seminole
Thomas
Worth

District 3

Chattahoochee
Crawford
Crisp
Dooly
Harris
Houston
Lee

District 3 (Cont)

Macon
Marion
Muscogee
Peach
Pulaski
Quitman
Randolph
Schley
Stewart
Sumter
Talbot
Taylor
Terrell
Webster

District 4

Butts
Carroll
Clayton
Coweeta
Douglass
Fayette
Fulton
Heard
Henry
Lamar
Meriweather
Newton
Pike
Rockdale
Spalding
Troup
Upson

District 5

Bacon
Ben Hill
Bleckley
Coffee

District 5 (Cont)

Dodge
Irwin
Jeff Davis
Laurens
Montgomery
Telfair
Tift
Toombs
Treutlen
Turner
Wheeler
Wilcox

District 6

Baldwin
Bibb
Glascock
Hancock
Jasper
Jefferson
Johnson
Jones
Monroe
Putnam
Twiggs
Washington
Wilkinson

District 7

Bartow
Catoosa
Chattooga
Cherokee
Cobb
Dade
Floyd
Gordon
Haralson
Murray

Georgia Forestry Commission (Continued)

District 7 (Cont)

Paulding
Pickens
Polk
Walker
Whitfield

District 8

Appling
Atkinson
Berrien
Brantley
Camden
Charlton
Clinch
Cook
Echols
Glynn
Lanier
Lowndes
Pierce
Ware
Wayne

District 9

Banks
Barrow
Dawson
Dekalb
Fannin
Forsyth
Franklin
Gilmer
Gwinnett
Habersham
Hall
Hart
Jackson
Lumpkin
Rabun
Stephens
Towns
Union
White

District 10

Clarke
Columbia
Elbert
Greene
Lincoln
Madison
Morgan
McDuffie
Oconee
Oglethorpe
Richmond
Talliferro
Walton
Warren
Wilkes

TABLE 3. Impact of Fusiform Rust on 8-12 Year Loblolly and Slash Pine Plantations in Georgia

District	LOBLOLLY (Percent of trees)*				SLASH (Percent of trees)*			
	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead
1	57	28	35	1	29	45	56	8
2	--	--	--	--	45	35	39	6
3	33	36	55	5	33	46	51	6
4	18	49	71	5	--	--	--	--
5	--	--	--	--	47	34	45	3
6	24	52	67	4	22	54	66	6
7	78	9	14	1	--	--	--	--
8	69	15	24	1	75	19	25	3
9	52	20	41	2	--	--	--	--
10	31	39	53	4	25	57	33	6
State Average	45	31	45	3	39	41	45	5

*Percent of trees do not add up to 100 percent because of category combinations.

Districts and Counties of the Florida Forest Service Surveyed for Fusiform Rust

District 1

Okaloosa
Santa Rosa
Escambia

District 2

Walton
Holmes
Washington
Jackson

District 3

Bay
Calhoun
Gulf
Liberty
Franklin

District 4

Gadsden
Wakulla
Leon
Jefferson

District 5

Madison
Taylor
Lafayette
Dixie

District 6

Hamilton
Swanee
Columbia
Baker

District 7

Nassau
Duval
Clay

District 8

Union
Bradford
Alachua
Putnam

District 9

Gilchrist
Levy
Marion

District 10

St. Johns
Flagler
Volusia

District 11

Sumter
Lake
Citrus
Hernando
Pasco

District 12

Seminole
Orange
Osceola
Brevard

TABLE 4. Impact of Fusiform Rust on 8-12 Year Slash Pine Plantations in Florida

SLASH
(Percent of trees)*

District	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead
1	88	7	11	1
2	60	22	32	2
3	82	15	12	2
4	57	25	30	6
5	67	20	27	2
6	66	17	26	2
7	86	9	9	1
8	84	10	7	2
9	97	3	3	1
10	95	4	2	1
11	98	2	1	1
12	99	1	1	0
13-14	99	1	0	0
State Average	83	10	12	2

*Percent of trees do not add up to 100 percent because of category combination.

Districts and Counties of the Louisiana Forestry Commission Surveyed for Fusiform Rust

District 1

St. Tammany
Tangipahoa
Washington

District 2

Allen
Evangeline

District 3

Caldwell
Grant
LaSalle
Winn

District 4

Bossier
Bienville
Caddo
Clairborn
Webster

District 5

Jackson
Lincoln
Morehouse
Ouachita
Union

District 6

DeSoto
Natchitoches
Red River
Sabine

District 7

Beauregard
Calcasieu
Vernon

District 8

Rapides

District 10

E. Feleciana
Livingston
St. Helena

TABLE 5. Impact of Fusiform Rust on 8-12 Year Loblolly and Slash Pine Plantations in Louisiana

District	LOBLOLLY (Percent of trees)*				SLASH (Percent of trees)*			
	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead
1	50	17	33	1	29	34	56	6
2	--	--	--	--	35	31	50	8
3	81	11	9	4	55	22	27	7
4	87	4	9	1	84	6	10	1
5	80	9	14	2	55	12	32	5
6	91	4	7	1	56	20	38	2
7	--	--	--	--	43	29	46	5
8	58	23	29	3	29	41	48	4
9	--	--	--	--	--	--	--	--
10	59	18	42	1	45	26	49	3
State Average	72	12	20	2	48	25	40	5

*Percent of trees do not add up to 100 percent because of category combinations.

Districts and Counties of the Mississippi Forestry Commission Surveyed for Fusiform Rust

Northeast

Alcorn
Benton
Chickasaw
Clay
Itawamba
Lee
Monroe
Pontotoc
Prentiss
Tippah
Tishomingo
Union

Northwest

Calhoun
Carroll
DeSoto
Grenada
LaFayette
Marshall
Montgomery
Panola
Tallahatchie
Tate
Webster
Yalobusha

West Central

Bolivar
Coahoma
Holmes
Humphreys
Issaquena
Leflore
Quitman
Sharkey
Sunflower

West Central (Cont)

Tunica
Warren
Washington
Yazoo

East Central

Attala
Choctaw
Kemper
Lauderdale
Leake
Lowndes
Madison
Neshuba
Newton
Noxubee
Oktibbeha
Scott
Winston

South Central

Clarke
Covington
Jasper
Jefferson Davis
Jones
Rankin
Simpson
Smith
Wayne

Southwest

Adams
Amite
Claiborne
Copiah
Franklin
Hinds
Jefferson
Lawrence
Lincoln
Pike
Walthall
Wilkinson

Southeast

Forrest
George
Greene
Hancock
Harrison
Jackson
Lamar
Marion
Pearl River
Perry
Stone

TABLE 6. Impact of Fusiform Rust on 8-12 Year Loblolly and Slash Pine Plantations in Mississippi

District	LOBLOLLY (Percent of trees)*				SLASH (Percent of trees)*			
	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead
Northeast	88	5	8	1	75	10	17	1
West Central	73	12	18	3	--	--	--	--
North West	91	5	5	1	--	--	--	--
South West	45	23	44	2	36	34	47	5
East Central	65	18	17	6	47	26	24	13
South East	58	6	34	4	45	17	43	6
South Central	52	22	33	7	60	18	27	5
State Average	67	13	23	3	53	21	32	7

*Percent of trees do not add up to 100 percent because of category combinations.

Districts and Counties of North Carolina Forest Service Surveyed for Fusiform Rust

District 3

Chatham
Lee
Moore
Richmond
Montgomery
Stanly
Anson
Scotland

District 4

Pitt
Beaufort
Lenoir
Jones
Craven
Pamilco
Onslow
Carteret

District 5

Warren
Halifax
Northampton
Franklin
Nash
Wilson
Wayne
Greene
Edgecombe

District 6

Johnston
Sampson
Cumberland
Harnett
Hoke
Robeson

District 7

Hertford
Bertie
Martin
Gates
Currituck
Chowan
Pasquotank
Camden
Perquimans

District 8

Bladen
Pender
New Hanover
Columbus
Brunswick
Duplin

District 10

Stokes
Rockingham
Forsyth
Guilford
Davie
Rowan
Davidson
Randolph

District 11

Caswell
Person
Granville
Alamance
Orange
Durham
Wake
Vance

District 12

Catawba
Lincoln
Cleveland
Gaston
Mecklenburg
Union
Cabarrus
Iredell

District 13

Washington
Tyrrell
Hyde

TABLE 7. Impact of Fusiform Rust on 8-12 Year Loblolly and Slash Pine Plantations in North Carolina

	LOBLOLLY (Percent of trees)*				SLASH (Percent of trees)*			
DISTRICT	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead
3	81	6	15	2	67	15	30	2
4	63	13	29	2	66	15	28	2
5	80	7	17	1	69	14	26	2
6	67	16	29	3	65	18	29	3
7	80	7	16	1	--	--	--	--
8	62	17	28	2	57	18	38	2
10	92	1	6	1	--	--	--	--
11	91	4	7	1	--	--	--	--
12	88	2	10	1	--	--	--	--
13	81	6	12	1	--	--	--	--
State Average	79	9	17	2	65	16	30	2

*Percent of trees do not add up to 100 percent because of category combinations.

Districts and Counties of the South Carolina Forestry Commission Surveyed for Fusiform Rust

District 1

Chesterfield
Kershaw
Lancaster
Lee
Richland
Sumter

District 2

Darlington
Dillon
Florence
Horry
Marion
Marlboro

District 3

Berkeley
Clarendon
Georgetown
Williamsburg

District 4

Abbeville
Chester
Edgefield
Fairfield
Greenwood
Laurens
McCormick
Saluda

District 5

Aiken
Allendale
Bamberg
Barnwell
Calhoun
Lexington
Orangeburg
Newberry

District 6

Anderson
Cherokee
Greenville
Oconee
Pickens
Spartanburg
Union
York

District 7

Beaufort
Charleston
Colleton
Dorchester
Hampton
Jasper

TABLE 8. Impact of Fusiform Rust on 8 - 12 Year Loblolly and Slash Pine Plantations in South Carolina

District	LOBLOLLY (Percent of trees)*				SLASH (Percent of trees)*			
	Healthy	Stem Cankers	Branch Cankers	Dead due to rust	Healthy	Stem Cankers	Branch Cankers	Dead due to rust
1	61	17	34	2	52	26	39	5
2	34	34	53	4	44	33	42	4
3	47	28	44	4	44	33	39	9
4	53	23	42	1	--	--	--	--
5	38	34	54	5	30	45	59	7
6	85	6	13	1	--	--	--	--
7	48	26	42	6	31	40	51	15
State Average	64	22	37	3	38	38	41	9

*Percent of trees do not add up to 100 percent because of category combinations.

TABLE 9. Impact Incidence Summary of Fusiform Rust on 8-12 Year Loblolly and Slash Pine Plantations in the Southeastern States

State	LOBLOLLY (Percent of trees)*				SLASH (Percent of trees)*			
	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead
Alabama	60	19	27	4	46	29	33	7
Arkansas	90	3	8	0	--	--	--	--
Georgia	45	31	45	3	39	41	45	5
Florida	--	--	--	--	83	10	12	2
Louisiana	72	12	20	2	48	25	40	5
Mississippi	67	13	23	3	53	21	32	7
North Carolina	79	9	17	2	65	16	30	2
South Carolina	64	22	37	3	38	38	41	9

*Percent of trees do not add up to 100 percent because of category combination.

FIGURE 1 -

PLOT DATA WORK SHEET - FUSIFORM RUST SURVEY

Data By _____ Date _____ Row # _____

Species _____ Age _____ Av. dbh _____ Av. Ht. _____

No. of rows in plantation _____ Acres _____

Location: State _____ County _____ Locality _____

Trees - Healthy			Trees - Diseased			Total Trees		
1			35			69		
2			36			70		
3			37			71		
4			38			72		
5			39			73		
6			40			74		
7			41			75		
8			42			76		
9			43			77		
10			44			78		
11			45			79		
12			46			80		
13			47			81		
14			48			82		
15			49			83		
16			50			84		
17			51			85		
18			52			86		
19			53			87		
20			54			88		
21			55			89		
22			56			90		
23			57			91		
24			58			92		
25			59			93		
26			60			94		
27			61			95		
28			62			96		
29			63			97		
30			64			98		
31			65			99		
32			66			100		
33			67					
34			68					

H=Canker Free S=Stem Canker B=Branch Canker SB=Stem & Branch Canker
SF=Dead Fusiform NM=Nonmerchantable

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More detailed information can be obtained by contacting the Forest Pest Management Group Field Offices listed below or the Atlanta Office:

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Alexandria Office Supervisor Forest Pest Management U.S. Forest Service 2500 Shreveport Highway Pineville, Louisiana 71360 Phone: (318) 445-6511 Ext. 311	Alabama Arkansas Louisiana Mississippi Oklahoma Texas

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APPENDIX 1

SURVEY FOR FUSIFORM RUST IN ALABAMA

A SURVEY FOR FUSIFORM RUST IN ALABAMA

William R. Phelps [1/], James R. Hyland [2/], & Carol Popowsky [1/]

ABSTRACT

A fusiform rust survey was conducted in Alabama during May and June, 1972. The entire State was grided at ten mile intervals, east-west and north-south. A plantation of slash and/or loblolly was sampled in the eight to twelve year age class that was located at or near the intersection of the grid lines. The survey was accomplished by the ratio estimation statistical survey method using three rows as the sample. Maps showing infection intensity for both slash and loblolly were prepared from the field data. Infection rates ranged from 2 to 94 percent for slash pine and 0 to 93 percent for loblolly pine. Impact of fusiform as determined by dead and other non-merchantable trees is included.

INTRODUCTION

According to the 1952 Timber Resources Review, fusiform rust of southern pine causes in the south a ten million dollar loss annually in sawtimber and 97 million cubic feet in growing stock. The incidence of rust is intensifying in some areas where slash and loblolly pine have been planted on former longleaf pine sites. As the supply of seedlings showing resistance to fusiform rust is limited, it is important that areas of high infection potential are known, so that the resistant seedlings can be planted in these areas and the more susceptible seedlings planted in areas where infection potential is not so great. No attempt has been made to make a south-wide survey for fusiform rust since 1939 (2). The University of Florida, Cooperative Tree Improvement Group, has completed a fusiform rust survey in slash pine in plantations of their cooperators in north Florida, south Georgia, and southern South Carolina (1). A survey was also conducted in South Carolina in 1964 whereby two plantations per county were sampled. Recently Yandle and Roth (8) developed a sampling method whereby pine plantations can be sampled by tallying rust infections on as few as three randomly selected rows in a plantation.

1/ Respectively, Area Staff Pathologist and Statistical Technician State & Private Forestry, Southeastern Area, U.S. Forest Service.

2/ Chief, Pest Control Section, Alabama Forestry Commission.

SURVEY METHODS

A survey using the Yandle-Roth method was conducted in Alabama during May and June, 1972. All of the counties in the State were surveyed, but plantations meeting the species and age requirements were not found in some of the counties in Districts 1, 2, 3, and 6. The entire State was grided on county maps, using ten mile square grids with lines running north-south and east-west. In the actual survey, a plantation in the correct age group (eight to twelve years) was selected for sampling where the north-south, east-west lines intersected. One plantation of slash pine and one plantation of loblolly pine were to be sampled at each intersection if available. There were 86 slash and 180 loblolly pine plantations sampled. The plantations sampled were ones in the eight to twelve year age group, closest to where the grid lines crossed and not over five miles from that point. Plantations of less than five acres in area and those that had previously been pruned or thinned were not considered. In general, loblolly pine was generally present throughout the whole state while slash pine was found in the central and southern part.

After selecting the plantation to be sampled, the rows were quickly counted and the three rows to be sampled were chosen by using a table of random numbers. The selected rows were then sampled, recording whether the trees were healthy, had a stem canker, had a branch canker, had both stem and branch canker, had been killed by fusiform, and if the tree was non-merchantable due to fusiform rust (Figure 1).

After the data were recorded for each county by State personnel, it was analyzed by personnel of State and Private Forestry, Southeastern Area. The preliminary analysis consisted of determining the percentage of infection for each plantation sampled. Using these percentages, maps were developed for both slash (Figure 2) and loblolly (Figure 3) pine, showing areas of infection as 0 to 25 percent, 26 to 50 percent, 51 to 75 percent and 76 percent plus. Table 1 shows the number of plantations sampled in each county and the range of infection for both slash and loblolly pine for the plantations sampled.

The Alabama Forestry Commission foresters feel "that planted pine stands with 50 percent or less infection with fusiform rust stem cankers can be successfully managed for pulpwood, lumber, and pole products. This 50 percent will be thinned in the first or second cutting, leaving non-infected trees for the longer rotations. There would be little effect, if any, if there were 50 percent branch canker infections, especially in the older plantations." Foresters should consider planting rust resistant seedlings in areas of heavy infection.

Field data collection was made by Alabama Forestry Commission foresters, county rangers, and patrolmen. A training session was held in Montgomery, Alabama, for district foresters. The training session was conducted by personnel of the U.S. Forest Service, Southeastern Area, State and Private Forestry.

The Alabama Forestry Commission personnel did an excellent job in collecting the field data. The survey was completed without unduly interfering with the normal workload of the Commission.

RESULTS AND DISCUSSION

Figures 2 and 3 show areas of infection intensity for both loblolly and slash pine, respectively. The absence of a species in this survey does not in fact mean that the species is absent from the area, but that it was not present in the age class required by the survey. The highest rust incidence for both slash and loblolly pine was found in a belt running southwest to northeast through the central and eastern part of the State. The highest incidence rates recorded in this survey was 94 percent for slash in Conecuh County and 93 percent for loblolly in Lowndes and Bullock Counties. The range of infection was 0 to 93 percent for loblolly pine and 2 to 94 percent for slash pine.

FUSIFORM RUST IMPACT

The percentages of healthy, stem cankered, branch cankered, and non-merchantable fusiform rust-killed trees are presented in Table 2. The tree percent is more than 100 because of the combination of infection categories. A total of 42,475 loblolly and 21,522 slash pines were used in this sample. Sixty percent of all the loblolly pines were healthy while forty-six percent slash pines did not have any infections. Only 19 percent of the loblolly pines had stem cankers while there were 29 percent in slash pines. Four and seven percent of 8-12 year old loblolly and slash pines, respectively, were dead or non-merchantable due to the rust. Percentages of dead and non-merchantable pines were highest in Districts 5 and 6. These impact results were very similar to those obtained in Mississippi. Although it appears that fusiform rust is not causing severe losses in this age group of pines for the whole State of Alabama, losses in other age groups may well exceed those found in this survey.

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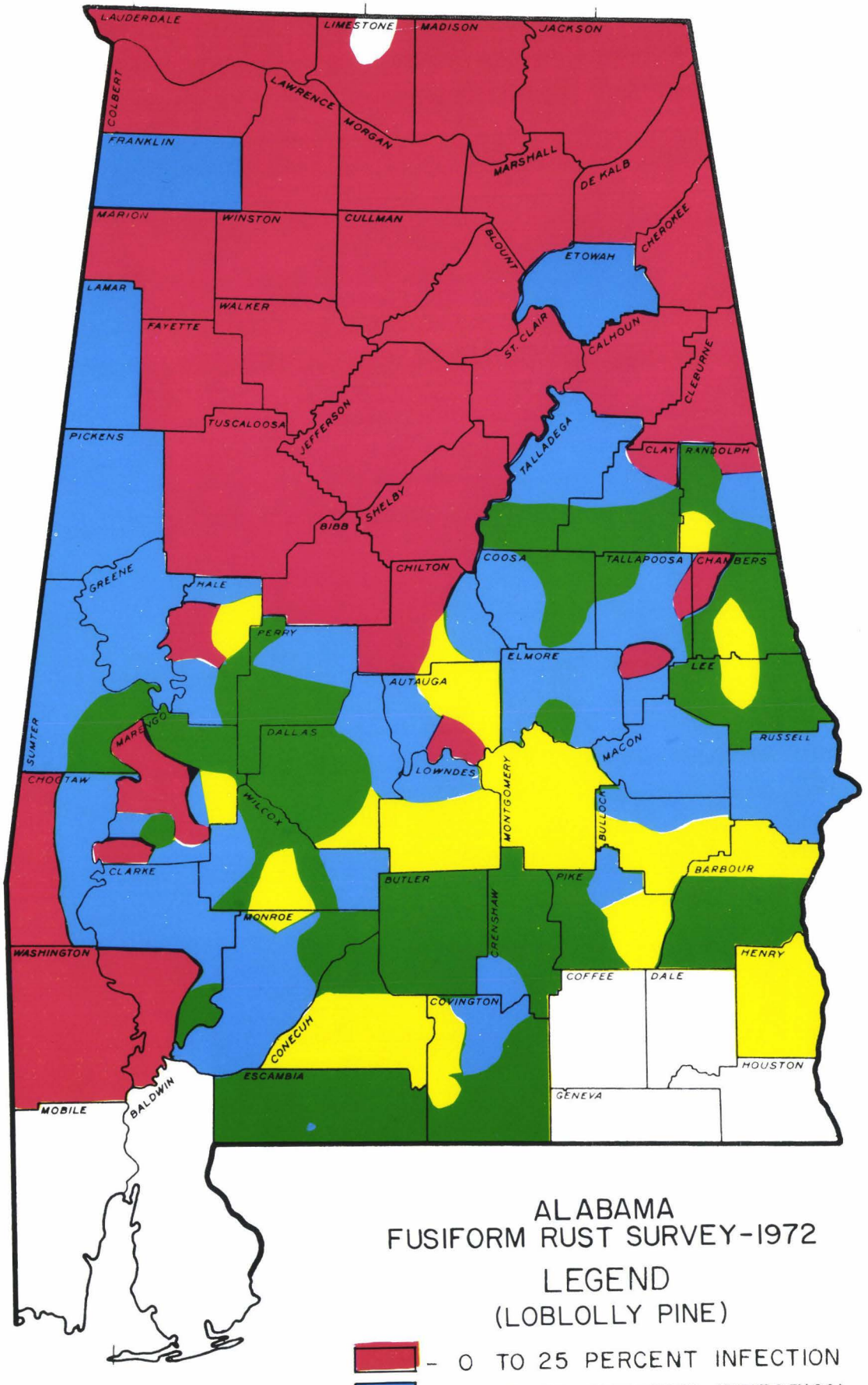
TABLE 1 - ALABAMA FUSIFORM RUST SURVEY - 1972

DISTRICT	COUNTY	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION			
		SLASH		LOBLOLLY	
		Number	Range (percent)	Number	Range (percent)
1	Colbert	0	--	1	5
	Etowah	0	--	1	36
	Franklin	0	--	1	28
	Lauderdale	0	--	2	0-7
	Limestone	0	--	4	5-32
	Madison	0	--	4	4-10
	Marshall	0	--	2	9-14
	Morgan	0	--	3	4-9
Total		0		18	
2	Cullman	0	--	3	5-19
	St.Clair	0	--	1	24
	Winston	0	--	1	24
Total		0		5	
3	Fayette	0	--	5	4-15
	Hale	1	47	3	23-78
	Pickens	0	--	1	41
	Sumter	0	--	6	31-60
	Tuscaloosa	0	--	4	6-23
Total		1		19	
4	Chambers	0	--	6	10-83
	Clay	1	66	6	39-70
	Cleburne	0	--	3	11-22
	Coosa	0	--	5	41-68
	Elmore	3	31-48	6	26-52
	Lee	2	62-70	6	43-88
	Randolph	0	--	6	15-80
	Talladega	0	--	7	37-64
	Tallapoosa	1	63	6	12-56
Total		7		51	

TABLE 1 - (Continued)

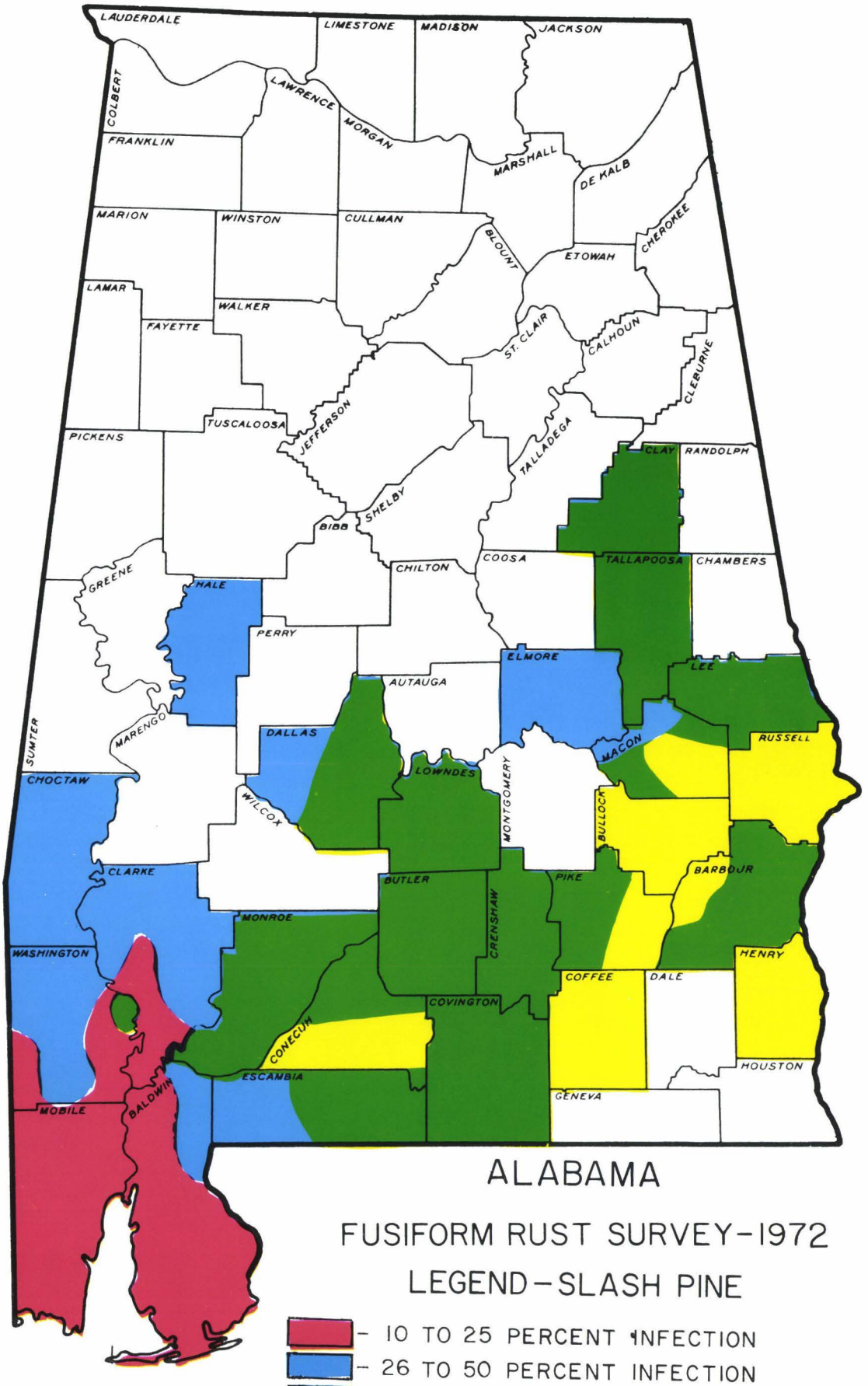
DISTRICT	COUNTY	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION			
		SLASH		LOBLOLLY	
		Number	Range (percent)	Number	Range (percent)
5	Autauga	0	--	4	15-74
	Chilton	0	--	7	16-76
	Dallas	2	54-61	5	43-76
	Lowndes	1	55	3	29-93
	Morengo	0	--	11	12-76
	Montgomery	0	--	1	86
	Perry	0	--	6	27-74
	Wilcox	0	--	11	43-81
Total		3		48	
6	Barbour	4	55-72	4	67-90
	Bullock	2	90-92	3	54-93
	Coffee	1	76	0	--
	Henry	4	83-88	1	90
	Macon	6	49-81	1	42
	Pike	5	72-84	2	47-58
	Russell	1	85	1	41
Total		23		12	
7	Butler	1	56	3	62-67
	Conecuh	5	70-94	5	74-84
	Covington	5	60-77	1	32
	Crenshaw	1	65	5	50-79
	Escambia	2	49-63	1	52
	Monroe	1	66	3	50-68
Total		15		18	
8	Baldwin	16	2-29	0	--
	Choctow	2	32-55	3	15-41
	Clarke	6	9-44	5	11-62
	Mobile	6	3-26	0	--
	Washington	7	8-68	1	19
Total		37		9	
Grand Total		86	46-65	180	27-53



ALABAMA
FUSIFORM RUST SURVEY-1972

LEGEND
(LOBLOLLY PINE)

- 0 TO 25 PERCENT INFECTION
- 26 TO 50 PERCENT INFECTION
- 51 TO 75 PERCENT INFECTION
- 76 + PERCENT INFECTION
- NO LOBLOLLY SAMPLED



ALABAMA

FUSIFORM RUST SURVEY-1972

LEGEND-SLASH PINE

- 10 TO 25 PERCENT INFECTION
- 26 TO 50 PERCENT INFECTION
- 51 TO 75 PERCENT INFECTION
- 76+ PERCENT INFECTION
- NOT SURVEYED OR NO SLASH SAMPLED

APPENDIX 2

SURVEY FOR FUSIFORM RUST IN ARKANSAS

A SURVEY FOR FUSIFORM RUST IN ARKANSAS

Elmer R. Roth and James V. Tiner [1/]

ABSTRACT

A fusiform rust survey was conducted in Arkansas during November and December, 1971, in districts 1, 2, 3, 5, 7, 8, and 9. These districts were grided at ten mile intervals, east-west and north-south. A plantation of loblolly pine was sampled in the eight to twelve year age class that was located at or near the intersection of the grid lines. The survey was accomplished by the ratio estimation statistical survey method using three rows as the sample. A map showing infection intensity for loblolly pine was prepared from the field data. Infection rates were low for the entire area sampled.

INTRODUCTION

According to the Timber Resources Review, fusiform rust of southern pine causes a ten million dollar loss annually in sawtimber and ninety-seven million cubic feet in growing stock. In some areas the incidence of rust is increasing where slash or loblolly have been planted on former longleaf sites. As the supply of seedlings showing resistance to fusiform rust is limited, it is important that areas of high infection potential are known so that resistant seedlings can be planted on these areas and the more susceptible seedlings planted on areas where the infection potential is not so great. No attempt has been made to make a southwide survey for fusiform rust since 1939 (2). The University of Florida, Cooperative Tree Improvement Group has completed a fusiform rust survey in slash pine in plantations of their cooperators in north Florida, south Georgia, and southern South Carolina (1). A survey was also conducted in South Carolina in 1964 whereby two

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1/ Respectively, Staff Pathologist, State and Private Forestry, Southeastern Area, and Chief, Forest Management, Arkansas Forestry Commission

plantations per county were sampled. Recently, Yandle and Roth (7) developed a sampling method whereby pine plantations can be sampled by tallying rust infections on as few as three randomly selected rows in a plantation. In this method both stem and branch cankers are recorded .

SURVEY METHODS

A survey using the Yandle-Roth method was conducted in Arkansas during November and December, 1971. The pine producing counties in districts 1, 2, 3, 5, 7, 8, and 9 were surveyed, but plantations meeting the species and age requirements were not found in Howard, Garland and Polk counties. The districts surveyed were grided on county maps, using ten mile square grids with lines running north-south and east-west. In the actual survey a plantation in the correct age group (eight to twelve years) was selected for sampling where the north-south, east-west lines intersected. The plantation sampled was one in the eight to twelve year age group, closest to where the grid lines crossed, and not over five miles from that point. A total of 106 loblolly plantations were sampled. Plantations of less than five acres in area and those that had previously been pruned or thinned were not considered. In the counties sampled only loblolly pine plantations were present in the age class required for the survey.

After selecting the plantation to be sampled, the rows were quickly counted and the three rows to be sampled were chosen by using a table of random numbers. The selected rows were then sampled, recording whether the trees were healthy, had a stem canker, had a branch canker, had both stem and branch cankers, or had been killed by fusiform rust (Figure 1).

After the data were recorded for each county by State personnel, it was analyzed by personnel of State and Private Forestry, Southeastern Area. The preliminary analysis consisted of determining the percentage of infection for each plantation sampled. Using these percentages, a map was developed (Figure 2) showing areas of infection as 0 to 25 percent; 26 to 50 percent; 51 to 75 percent and 76 percent plus. Table 1 shows the number of plantations sampled in each county and the range of infection for the plantations sampled.

As percent infected includes both stem and branch cankers, it is the opinion of most management foresters that stands with 50 percent or less infection can be successfully managed for pulpwood, lumber and pole products. With random infection, adequate stocking would still be maintained even though as many as 50 percent were infected. Special consideration should be given to areas where the infection is greater than 50 percent.

If there are areas of heavy infection that were missed in this survey, foresters should consider planting resistant seedlings in those areas.

Field data collection was accomplished by Arkansas Forestry Commission foresters. A total of two training sessions were held in the state for District Foresters, by personnel of the U. S. Forest Service, Southeastern Area, State and Private Forestry. The training sessions were held in El Dorado and Fordyce. A forester from the Arkansas Forestry Commission attended each of the training sessions.

The Arkansas Forestry Commission did a very efficient job of collecting the data. The survey was completed in the alloted time without unduly interfering with the workload or causing a hardship on any of the foresters.

RESULTS AND DISCUSSION

Figure 2 shows areas of infection intensity for loblolly pine in south Arkansas. Slash pine plantations of the correct age were not present in the area surveyed. In general, the amount of infection was low, with only two plots in Ouachita County being over 30 percent. The highest percentage of infection was 44 percent and the lowest was zero. The average range of infection for the plantations examined was 4 to 18 percent. The low percentage of infection for the plantations examined does not rule out the possibility that there may be an occasional plantation with more infection. From the results of this survey, indications are that fusiform rust is not a serious problem on loblolly pine in Arkansas. The map for loblolly pine (4) in Louisiana also shows a low incidence of rust infection in northern Louisiana.

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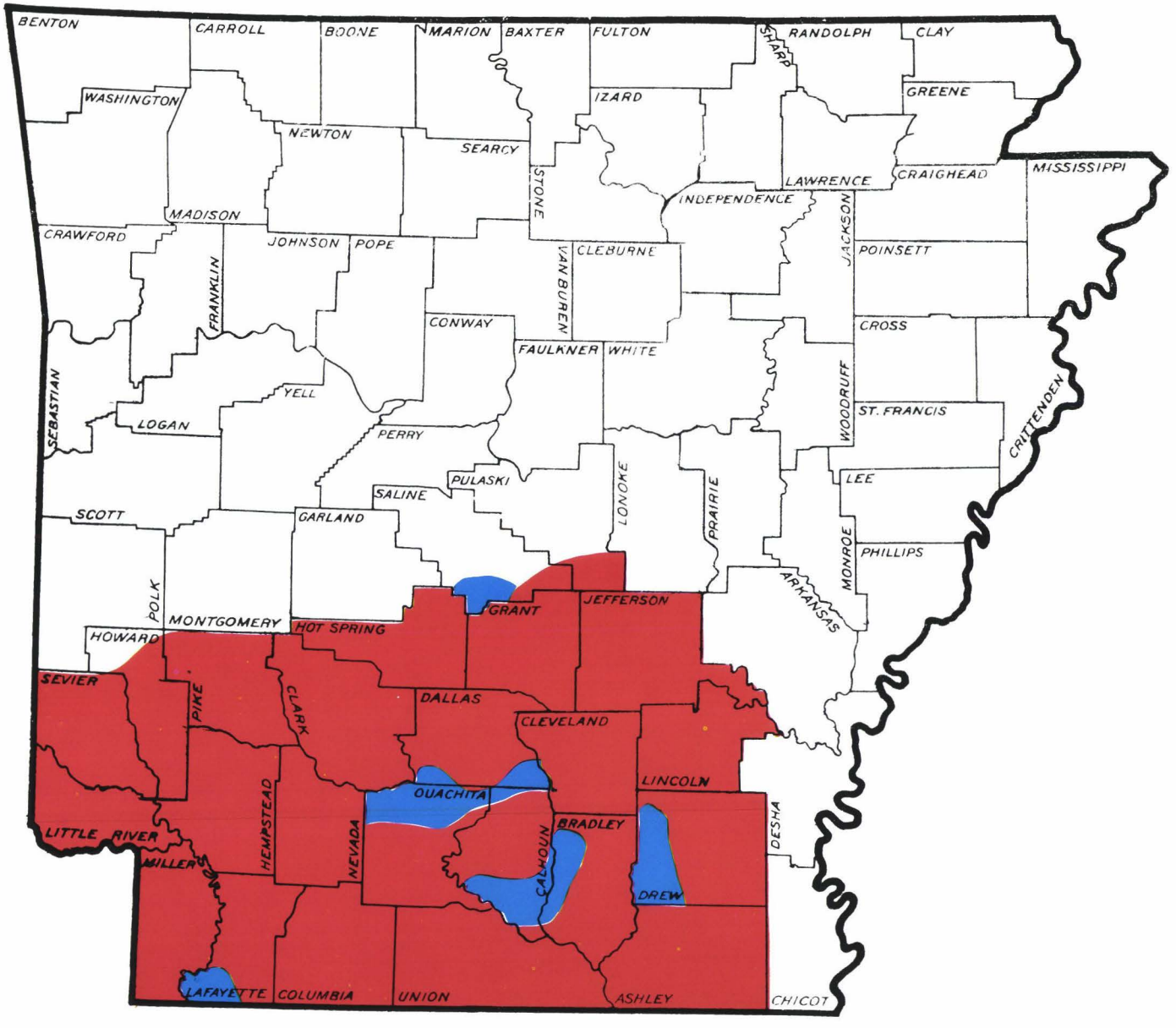
TABLE 1 - ARKANSAS FUSIFORM RUST SURVEY - 1971

DISTRICT	COUNTY	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION: NUMBER	RANGE (Percent)
1	Ashley	6	6-19
	Drew	7	5-27
	Lincoln	3	6-10
Total		16	
2	Hemstead	3	3-8
	Howard	0	--
	Little River	4	4-13
	Pike	4	0-9
	Polk	0	--
	Sevier	2	0-5
Total		13	
3	Bradley	7	9-30
	Calhoun	5	11-30
	Cleveland	5	3-14
	Dallas	7	1-27
	Ouachita	7	12-44
Total		31	
5	Clark	7	3-17
	Garland	0	--
	Hot Springs	2	1-3
	Saline	5	0-28
Total		14	
7	Grant	4	1-14
	Jefferson	2	6
	Pulaski	1	8
Total		7	
8	Union	6	1-18

TABLE 1 - (Continued)

DISTRICT	COUNTY	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION: NUMBER	RANGE(Percent)
9	Columbia	7	2-17
	Lafayette	3	2-27
	Miller	5	2-13
	Nevada	4	7-19
Total		19	
GRAND TOTAL		106	4-18

ARKANSAS



FUSIFORM RUST SURVEY – 1971

LEGEND - LOBLOLLY PINE

- 0 TO 25 PERCENT INFECTION
- 26 TO 50 PERCENT INFECTION
- NO LOBLOLLY SAMPLED

APPENDIX 3

SURVEY FOR FUSIFORM RUST IN GEORGIA

A SURVEY FOR FUSIFORM RUST IN GEORGIA

By Elmer R. Roth and W. H. McComb[1/]

ABSTRACT

A fusiform rust survey was conducted in Georgia during October and November, 1971. The entire state was grided at ten mile intervals, east-west and north-south. A plantation of slash and/or loblolly pine was sampled in the eight to twelve year age class that was located at or near the intersection of the grid lines. The survey was accomplished by the ratio estimation statistical survey method using three rows as the sample. Maps showing infection intensity for both slash and loblolly pine were prepared from the field data. Average infection rates were very similar in both slash and loblolly pines.

INTRODUCTION

According to the Timber Resources Review, fusiform rust of southern pine causes a ten million dollar loss annually in sawtimber and 97 million cubic feet in growing stock. The incidence of rust is intensifying in areas where slash and loblolly pine have been planted on former longleaf pine sites. As the supply of seedlings showing resistance to fusiform rust is limited, it is important that areas of high infection potential are known, so that the resistant seedlings can be planted on these areas and the more susceptible seedlings planted on areas where infection potential is not so great. No attempt has been made to make a southwide survey for fusiform rust since 1939 (2). The University of Florida, Cooperative Tree Improvement Group, has completed a fusiform rust survey in slash pine in plantations of their cooperators in north Florida, south Georgia and southern South Carolina (1). A survey was also conducted in South Carolina in 1964 whereby two plantations per county were sampled. Recently, Yandle and Roth (6) developed a sampling method whereby pine plantations can be sampled by tallying rust infections on as few as three randomly selected rows in a plantation. In this method both stem and branch cankers are recorded.

[1/]Respectively, Staff Pathologist, State and Private Forestry, Southeastern Area; and Chief, Forest Management, Georgia Forestry Commission.

SURVEY METHODS

A survey using the Yandle-Roth method was conducted in Georgia during October and November, 1971. All of the counties in the state were surveyed, but plantations meeting the species and age requirements were not found in a few extreme northeast counties. The entire state was grided on county maps, using ten mile square grids with lines running north-south and east-west. In the actual survey, a plantation in the correct age group (eight to twelve years) was selected for sampling where the north-south, east-west lines intersected. One plantation of slash pine and one plantation of loblolly pine were to be sampled at each intersection, if available. There were 349 slash and 182 loblolly pine plantations sampled. The plantations sampled were ones in the eight to twelve year age group, closest to where the grid lines crossed, and not over five miles from that point. Plantations of less than five acres in area and those that had previsouly been pruned or thinned were not considered. In general, slash pine was present in the southern part of the state and loblolly in the north. Both slash and loblolly pine were available for sampling along the fall line (a line running roughly from Augusta to Macon to Columbus).

After selecting the plantation to be sampled, the rows were quickly counted and the three rows to be sampled were chosen by using a table of random numbers. The selected rows were then sampled, recording whether the trees were healthy, had a stem canker, had a branch canker, had both stem and branch cankers, or had been killed by fusiform rust. (Figure 1)

After the data were recorded for each county by state personnel, it was analyzed by personnel of State and Private Forestry, Southeastern Area. The preliminary analysis consisted of determining the percentage of infection for each plantation sampled. Using these percentages, maps were developed for both slash (Figure 2) and loblolly (Figure 3) pine showing areas of infection as 0 to 25 percent, 26 to 50 percent, 51 to 75 percent and 76 percent plus. Table 1 shows the number of plantations sampled in each county and the range of infection for both slash and loblolly pine for the plantations sampled. Districts number 1, 2, 5, and 8 were almost devoid of loblolly pine while districts 7 and 9 did not have any slash pine in the correct age group.

As percent infected includes both stem and branch cankers, it is the opinion of most management foresters that stands with 50 percent or less infection can be successfully managed for pulpwood, lumber, and pole products. Spacing of seedlings would allow for adequate stocking even though as many as 50 percent were infected. Special consideration should be given to those areas where infection is greater than 50 percent.

Foresters should consider planting seedlings that show resistance to fusiform rust in areas of heavy infection.

Field data collection was made by Georgia Forestry Commission foresters. A total of three training sessions were held in the state for district and county foresters by personnel of the U. S. Forest Service, Southeastern Area, State and Private Forestry. These training sessions were held in Atlanta, Macon and Waycross. Georgia Forestry Commission foresters attended these training sessions.

The Georgia Forestry Commission did an excellent and efficient job in collecting the data. The survey was completed in the alloted time without unduly interfering with the normal workload or causing a hardship on any of the foresters.

RESULTS AND DISCUSSION

Figures 2 and 3 show areas of infection intensity for both slash and loblolly pine respectively. Loblolly pine was present mostly north and along the fall line while slash pine was found south and along the fall line. The absence of a species in this survey does not in fact mean that the species is absent from the area, but that it was not present in the age class required for the survey. Where slash and loblolly were found in the same general area there was not much difference in amount of infection. In general, the amount of infection was higher along the fall line for both species. The highest rates of infection recorded in this survey were 100 percent for loblolly in Heard County and 97 percent for slash in Butts County. The average range of infection intensity was very similar in both slash (50-72 percent) and loblolly pine (53-64 percent). An examination of the maps show a layering effect in loblolly, with progressively more infection from north to south, while slash shows a general increase from south to north. If we compare the slash pine map (Figure 2) with the Florida map (3) and Figures 2 and 3 with the South Carolina map (5) it will be noted that rates of infection match fairly well between the three state maps.

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Table 1 - Georgia Fusiform Rust Survey - 1971

DISTRICT	COUNTY	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION			
		SLASH		LOBLOLLY	
		NO.	RANGE(%)	NO.	RANGE(%)
1	Bryan	5	24-86	-	-
	Bullock	7	64-77	-	-
	Burke	7	72-87	-	-
	Candler	3	68-87	-	-
	Chatham	3	58-62	1	43
	Effingham	5	52-79	-	-
	Emanuel	6	60-82	-	-
	Evans	1	69	-	-
	Jenkins	3	80-85	-	-
	Liberty	5	68-77	-	-
	Long	5	30-87	-	-
	McIntosh	4	29-75	-	-
	Screven	6	75-85	-	-
	Tattnall	5	36-79	-	-
TOTAL		65		1	
2	Baker	4	37-72	-	-
	Brooks	6	76-86	-	-
	Calhoun	2	67-83	-	-
	Clay	3	62-74	-	-
	Colquitt	5	60-77	-	-
	Decatur	4	15-25	-	-
	Dougherty	3	33-79	-	-
	Early	6	62-81	-	-
	Grady	5	34-66	-	-
	Miller	5	18-77	-	-
	Mitchell	6	30-71	-	-
	Seminole	2	15-35	-	-
	Thomas	6	41-83	-	-
	Worth	5	38-67	-	-
TOTAL		62		0	
3	Chattahoochee	2	35-38	-	-
	Crawford	4	50-70	-	-
	Crisp	4	45-78	-	-
	Dooly	4	63-88	-	-
	Harris	1	53	4	53-89
	Houston	4	72-86	-	-
	Lee	4	58-78	-	-
	Macon	3	82-85	-	-
	Marion	2	47	-	-
	Muscogee	2	61-76	2	68-71

DISTRICT	COUNTY	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION			
		SLASH		LOBLOLLY	
		NO.	RANGE(%)	NO.	RANGE(%)
3	Peach	-	-	1	43
(Contd)	Pulaski	4	75-90	-	-
	Quitman	2	67-71	1	92
	Randolph	5	70-82	2	37-40
	Schley	1	78	1	88
	Stewart	5	52-79	4	52-70
	Sumter	5	63-76	1	77
	Talbot	2	37-74	3	63-81
	Taylor	5	41-68	-	-
	Terrell	3	63-90	1	90
	Webster	2	68-74	-	-
TOTAL		64		20	
4	Butts	-	-	1	97
	Carroll	-	-	4	85-96
	Clayton	-	-	-	-
	Coweeta	-	-	4	88-96
	Douglass	-	-	1	94
	Fayette	-	-	1	89
	Fulton	-	-	4	35-99
	Heard	-	-	2	48-100
	Henry	-	-	2	76-79
	Lamar	-	-	2	75-84
	Meriweather	1	92	4	75-96
	Newton	-	-	3	75-89
	Pike	-	-	2	77-83
	Rockdale	-	-	-	-
	Spalding	-	-	4	67-88
	Troup	1	93	2	82-83
	Upson	-	-	4	85-93
TOTAL		2		40	
5	Bacon	2	16	-	-
	Ben Hill	3	56-76	-	-
	Bleckley	1	89	-	-
	Coffee	7	22-53	-	-
	Dodge	5	42-83	-	-
	Irwin	3	26-45	-	-
	Jeff Davis	3	14-62	-	-
	Laurens	8	63-81	-	-
	Montgomery	3	32-81	-	-
	Telfair	4	36-75	-	-
	Tift	3	45-72	-	-
	Toombs	3	32-69	-	-
	Treutlen	2	67-72	-	-
	Turner	2	45-63	-	-
	Wheeler	4	54-84	-	-
	Wilcox	4	28-68	-	-
TOTAL		57		0	

DISTRICT	COUNTY	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION			
		SLASH		LOBLOLLY	
		NO.	RANGE(%)	NO.	RANGE(%)
6	Baldwin	1	65	2	60-72
	Bibb	1	78	1	70
	Glascock	1	69	-	-
	Hancock	1	87	3	77-83
	Jasper	-	-	1	73
	Jefferson	5	77-87	2	76-89
	Johnson	2	71-74	-	-
	Jones	-	-	-	-
	Monroe	-	-	2	55-60
	Putnam	-	-	-	-
	Twiggs	2	69-78	1	87
	Washington	5	86-92	-	-
	Wilkinson	4	63-82	1	71
TOTAL		22		13	
7	Bartow	-	-	3	16-46
	Catoosa	-	-	1	10
	Chattooga	-	-	5	16-33
	Cherokee	-	-	2	30-48
	Cobb	-	-	3	31-67
	Dade	-	-	1	22
	Floyd	-	-	5	7-19
	Gordon	-	-	3	3-13
	Haralson	-	-	4	27-69
	Murray	-	-	2	5-15
	Paulding	-	-	4	16-38
	Pickens	-	-	2	8-10
	Polk	-	-	2	17-29
	Walker	-	-	1	6
	Whitfield	-	-	3	3-10
TOTAL		0		41	
8	Appling	5	15-38	-	-
	Atkinson	2	24-53	-	-
	Berrien	5	35-86	-	-
	Brantley	5	18-28	-	-
	Camden	7	25-78	-	-
	Charlton	6	15-49	1	34
	Clinch	8	5-29	-	-
	Cook	2	54-55	-	-
	Echols	5	10-81	-	-
	Glynn	2	42-57	-	-
	Lanier	2	25-82	-	-
	Lowndes	6	62-81	-	-
	Pierce	3	14-24	-	-
	Ware	6	8-78	-	-
	Wayne	6	6-53	1	23
TOTAL		70		2	

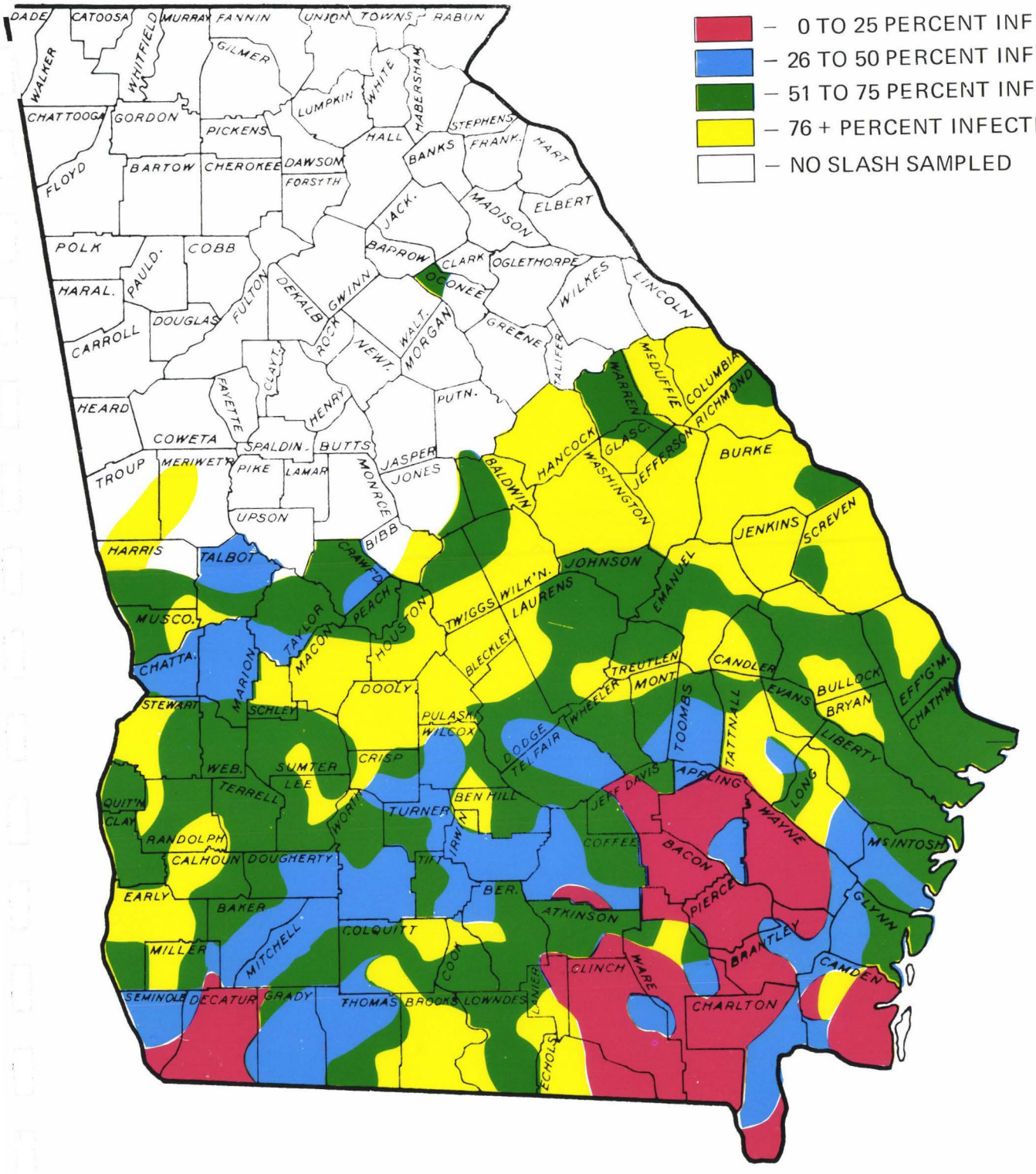
DISTRICT	COUNTY	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION			
		SLASH		LOBLOLLY	
		NO.	RANGE(%)	NO.	RANGE(%)
9	Banks	-	-	3	19-58
	Barrow	-	-	2	71-75
	Dawson	-	-	-	-
	Dekalb	-	-	1	91
	Fannin	-	-	-	-
	Forsyth	-	-	2	35-51
	Franklin	-	-	4	15-38
	Gilmer	-	-	-	-
	Gwinnett	-	-	4	69-89
	Habersham	-	-	1	16
	Hall	-	-	1	32
	Hart	-	-	4	19-61
	Jackson	-	-	2	49-65
	Lumpkin	-	-	1	61
	Rabun	-	-	-	-
	Stephens	-	-	2	9-13
	Towns	-	-	-	-
	Union	-	-	-	-
	White	-	-	-	-
TOTAL		0		27	
10	Clarke	-	-	1	81
	Columbia	-	-	3	61-82
	Elbert	-	-	4	57-71
	Greene	-	-	3	53-70
	Lincoln	-	-	3	43-62
	Madison	-	-	2	36-74
	Morgan	-	-	3	75-78
	McDuffie	2	76-84	1	68
	Oconee	1	63	3	71-82
	Oglethorpe	-	-	4	34-69
	Richmond	3	64-82	1	57
	Talliferro	-	-	1	68
	Walton	-	-	2	82-83
	Warren	1	75	3	76-88
	Wilkes	-	-	4	63-71
TOTAL		7		38	
GRAND TOTAL		349	50-72	182	53-64

GEORGIA

FUSIFORM RUST SURVEY – 1971

LEGEND - SLASH PINE

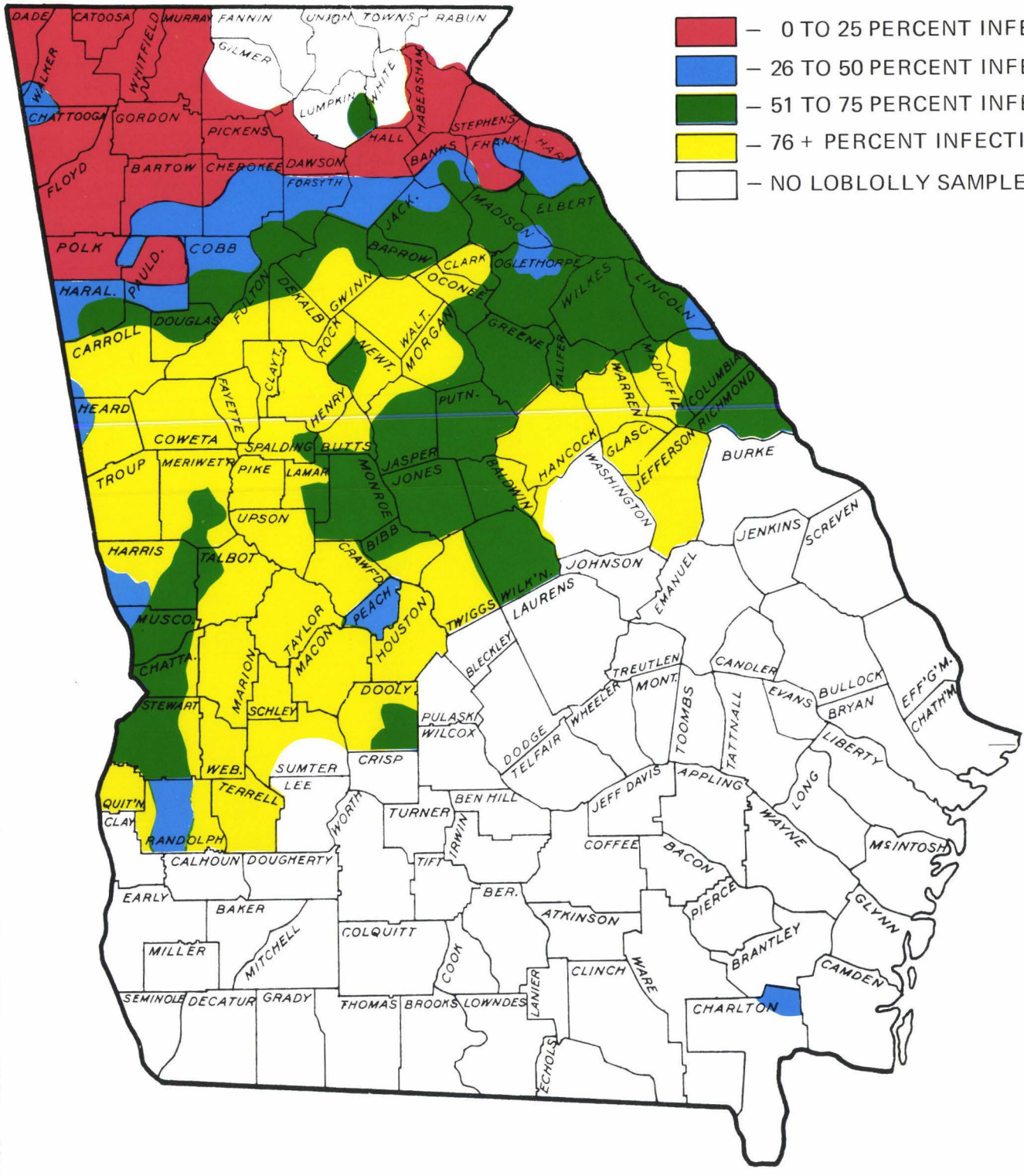
- 0 TO 25 PERCENT INFECTION
- 26 TO 50 PERCENT INFECTION
- 51 TO 75 PERCENT INFECTION
- 76 + PERCENT INFECTION
- NO SLASH SAMPLED



GEORGIA

FUSIFORM RUST SURVEY – 1971

LEGEND – LOBLOLLY PINE



APPENDIX 4

SURVEY FOR FUSIFORM RUST IN FLORIDA

A SURVEY FOR FUSIFORM RUST IN FLORIDA

Elmer R. Roth and Charles W. Chellman [1/]

ABSTRACT

A fusiform rust survey was conducted in Florida during March and April 1971. The State was grided at 10 mile intervals, east-west and north-south. A plantation was sampled in the 8 - 12 year age class, that was located at or near the intersection of the grid lines. The survey was accomplished by the ratio estimation statistical method using only three rows as the sample. A map showing infection intensity was prepared from the field data. Counties south of Alachua and Putnam had less than 12 percent infection in the plantations sampled.

According to the 1952 Timber Resources Review, fusiform rust of southern pine causes more than a ten million dollar loss annually in saw timber and 97 million cubic feet in growing stock. The incidence of rust is intensifying in areas where slash and loblolly pine has been planted on former longleaf sites. As the supply of seedlings showing resistance to fusiform rust is limited, it is important that areas of high infection potential is known, so that the resistant seedlings can be planted on these areas and the more susceptible seedlings planted on areas where infection potential is not as great. No attempt has been made to make a southwide survey for fusiform rust since 1939 (1). The University of Florida, Cooperative Tree Improvement Group, has completed a fusiform rust survey in slash pine in plantations of their cooperators in north Florida, south Georgia and southern South Carolina. Recently Yandle and Roth (2) developed a sampling method whereby pine plantations can be sampled by tallying infection on as few as 3 randomly selected rows in a plantation. In this method, both stem and branch cankers are recorded.

A survey using the above method was begun in Florida on March 2, 1971, and completed April 30, 1971. All of the State lying north of

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1/ Respectively, Staff Pathologist, Division of Forest Pest Control, Southeastern Area, U.S. Forest Service and Entomologist, Florida Forest Service.

Manatee, Hardee, Okeechobee and Indian River Counties was surveyed. That part of the State to be surveyed was laid off on county maps using 10 mile square grids with lines running north and south and east and west. In the actual survey a plantation in the correct age group (8 - 12 years) was selected for sampling. With few exceptions, all of the plantations sampled in Florida were slash pine. The plantation to be sampled was the one of the correct age, closest to where the grid lines crossed, and not over 5 miles from this point. Plantations less than 5 acres in area, and those which had been previously pruned or thinned, were not considered.

After selecting the plantation to be sampled, the rows were quickly counted and the three rows to be sampled were chosen by using a table of random numbers. The selected rows were then sampled indicating whether the trees were healthy, had a stem canker, had a branch canker, had both stem and branch cankers, or had been killed by fusiform (figure 1).

After the data was collected for each of the counties surveyed, it was analyzed by the Environmental Protection and Improvement Unit, Southeastern Area. The preliminary analyses consisted of determining the percentage of infection for each plantation sampled. Using these percentages of infection, a map was developed (figure 2) showing areas of infection as 0 to 25 percent, 26 to 50 percent, 51 to 75 percent and 76 plus percent. Table 1 shows the number of plantations sampled in each county and the range of infection for the plantations sampled. Counties in Districts 15, 16, 17, and 18 were not surveyed because of extremely low rust hazard.

It is the opinion of the management foresters in the State organization that areas with less than 50 percent infection (includes both stem and branch cankers) can be successfully managed for pulpwood, timber, and pole products. Where infection is greater than 50 percent these areas should be given special consideration. In areas of heavy infection, foresters should consider planting seedlings that have shown resistance to the rust.

Physical completion of the survey was accomplished by personnel of the Florida Division of Forestry (County Foresters and Rangers). A series of training sessions were conducted for the State personnel by the Environmental Protection and Improvement Unit, Southeastern Area, State and Private Forestry.

The Florida Division of Forestry did an excellent and efficient job in collecting the data. This project was completed in a short time without unduly interfering with their normal workload.

The map included with the report shows areas of infection intensity. The only areas of concern are limited to relatively small areas in the northernmost tier of counties. Some of the plantations sampled in the southernmost counties were free of any infection. Highest infection was 94 percent in Jefferson County. Generally speaking, the areas where infection is over 50 percent, are very limited.

LITERATURE CITED

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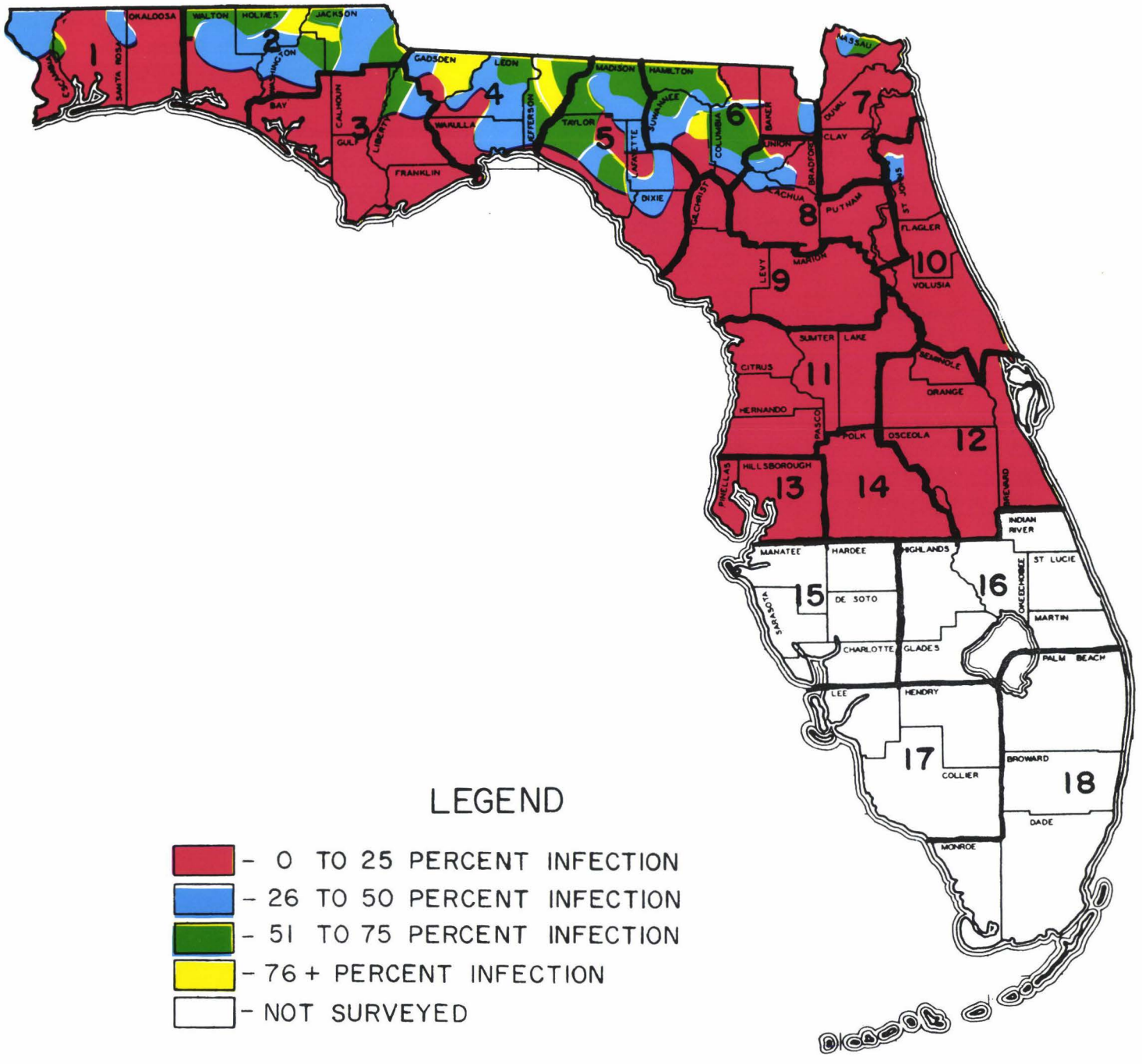
TABLE 1

FLORIDA FUSIFORM RUST SURVEY - 1971

County	Number of Plantations	Range of Infection	County	Number of Plantations	Range of Infection
Alachua	8	6 - 27	Leon	6	12 - 54
Baker	4	4 - 42	Levy	5	0 - 11
Bay	5	1 - 12	Liberty	6	2 - 68
Bradford	3	5 - 49	Madison	5	29 - 70
Brevard	1	1 - 1	Marion	10	1 - 10
Calhoun	6	4 - 25	Nassau	8	8 - 69
Citrus	7	0 - 2	Okaloosa	8	1 - 26
Clay	6	2 - 19	Orange	5	0 - 1
Columbia	7	5 - 61	Osceola	1	0 - 0
Dixie	7	1 - 29	Pasco	2	0 - 1
Duval	6	4 - 16	Pinellas	2	0 - 0
Escambia	6	3 - 50	Polk	13	0 - 3
Flagler	4	1 - 20	Putnam	8	1 - 5
Franklin	6	- - -	Santa Rosa	10	1 - 52
Gadsden	6	5 - 78	Seminole	1	1 - 1
Gilchrist	2	5 - 5	St. Johns	7	1 - 26
Gulf	4	0 - 10	Sumter	2	0 - 0
Hamilton	6	42 - 73	Suwanee	7	14 - 84
Hernando	6	0 - 12	Taylor	11	2 - 58
Hillsboro	3	0 - 0	Union	3	6 - 57
Holmes	6	47 - 82	Volusia	8	0 - 3
Jackson	9	32 - 76	Wakulla	5	7 - 46
Jefferson	4	70 - 94	Walton	11	5 - 60
Lafayette	7	15 - 47	Washington	7	15 - 65
Lake	6	0 - 1			

FLORIDA FUSIFORM RUST SURVEY - 1971



LEGEND

- 0 TO 25 PERCENT INFECTION
- 26 TO 50 PERCENT INFECTION
- 51 TO 75 PERCENT INFECTION
- 76 + PERCENT INFECTION
- NOT SURVEYED

APPENDIX 5

SURVEY FOR FUSIFORM RUST IN LOUISIANA

A SURVEY FOR FUSIFORM RUST IN LOUISIANA

Elmer R. Roth and L. H. Nachod [1/]

ABSTRACT

A fusiform rust survey was conducted in Louisiana during July and August, 1971. That portion of the State to be surveyed was grided at 10 mile intervals, east-west and north-south. A plantation of slash and/or loblolly pine was sampled in the 8 - 12 year age class that was located at or near the intersection of the grid lines. The survey was accomplished by the ratio estimation statistical method using only three rows as the sample. Maps showing infection intensity for both slash and loblolly pine were prepared from the field data. Parishes not listed in the table were not surveyed because of lack of pine plantations. Slash pine showed a higher infection intensity than did loblolly pine.

INTRODUCTION

According to the 1952 Timber Resources Review, fusiform rust of southern pine causes more than a ten million dollar loss annually in saw timber and 97 million cubic feet in growing stock. The incidence of rust is intensifying in areas where slash and loblolly pine have been planted on former longleaf sites. As the supply of seedlings showing resistance to fusiform rust is limited, it is important that areas of high infection potential are known, so that the resistant seedlings can be planted on these areas and the more susceptible seedlings planted on areas where infection potential is not so great. No attempt has been made to make a southwide survey for fusiform rust since 1939 (2). The University of Florida, Cooperative Tree Improvement Group, has completed a fusiform rust survey in slash pine in plantations of their cooperators in north Florida, south Georgia, and southern South Carolina (1). A survey was also conducted in South Carolina in 1964 whereby two plantations per

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1/ Respectively, Staff Pathologist, State and Private Forestry, Southeastern Area, U.S. Forest Service and Staff Forester, Louisiana Forestry Commission.

county were sampled. Recently Yandle and Roth (4) developed a sampling method whereby pine plantations can be sampled by tallying infection on as few as three randomly selected rows in a plantation. In this method both stem and branch cankers are recorded.

SURVEY METHODS

A survey using the above method was conducted in Louisiana during July and August, 1971. All of the parishes listed in Table 1 were surveyed. That part of the State to be surveyed was laid off on parish maps using 10 mile square grids with lines running north-south and east-west. In the actual survey a plantation in the correct age group (8 - 12 years) was selected for sampling where the north-south, east-west lines intersected. The work plan called for one plantation of slash pine and one plantation of loblolly pine to be sampled at each intersection if available. There were 126 slash pine and 115 loblolly pine plantations sampled. The plantations sampled were ones in the correct age group, closest to where the grid lines crossed, and not over five miles from that point. Plantations less than five acres in area, and those which had previously been pruned or thinned were not considered.

After selecting the plantation to be sampled, the rows were quickly counted and the three rows to be sampled were chosen by using a table of random numbers. The selected rows were then sampled indicating whether the trees were healthy, had a stem canker, had a branch canker, had both stem and branch cankers, or had been killed by fusiform (Figure 1).

After the data was collected for each of the parishes surveyed by the State personnel, it was analyzed by State and Private Forestry, Southeastern Area. The preliminary analysis consisted of determining the percentage of infection for each plantation sampled. (Plantations were not always available at points where the grid lines intersected.) Using these percentages of infection, maps were developed for both slash (Figure 2) and loblolly (Figure 3) pines showing areas of infection as 0 to 25 percent, 26 to 50 percent, 51 to 75 percent and 76 percent plus. Table 1 shows the number of plantations sampled in each parish and the range of infection for both slash and loblolly for the plantations sampled. Parishes in Districts 9 and 10 and parts of Districts 1, 2, 5, 7, and 8 were not sampled because forested areas were largely hardwoods.

As percent infected includes both stem and branch cankers, it is the opinion of management foresters that stands with 50 percent or less infection can be successfully managed for pulpwood, lumber and pole products. Special consideration should be given to those areas where infection is greater than 50 percent. In areas of heavy infection foresters should consider planting seedlings that have shown resistance to the rust.

Physical completion of the survey was accomplished by personnel of the Louisiana Forestry Commission (Parish Foresters and Rangers). A training session was conducted at Woodworth, Louisiana, for District Foresters by personnel of the U.S. Forest Service, Southeastern Area, State and Private Forestry. Additional training was given the parish foresters and rangers by the district foresters and the staff forester in charge of insect and disease control.

The Louisiana Forestry Commission did an excellent and efficient job in collecting the data. The project was completed in a short time without unduly interfering with their normal workload.

RESULTS AND DISCUSSION

The maps (Figure 2, Slash and Figure 3, Loblolly) show areas of infection intensity for both slash and loblolly pine for the parishes surveyed. Slash pine was more common in the southern parishes and loblolly pine in the northern parishes. Where the two species were found in the same general area, slash pine was more heavily infected. (Compare maps figure 2 and 3 and range of infection in Table 1.) Of the 24 parishes where loblolly was sampled, only four had infection rates above 50 percent. The infection rate was above 50 percent in 21 of the 25 parishes sampled where slash was present. The highest infection rate of 87 percent was found in slash pine in Tangipahoa Parish. In general, infection rates of more than 50 percent in loblolly pine are very limited while in slash these infection rates are more numerous.

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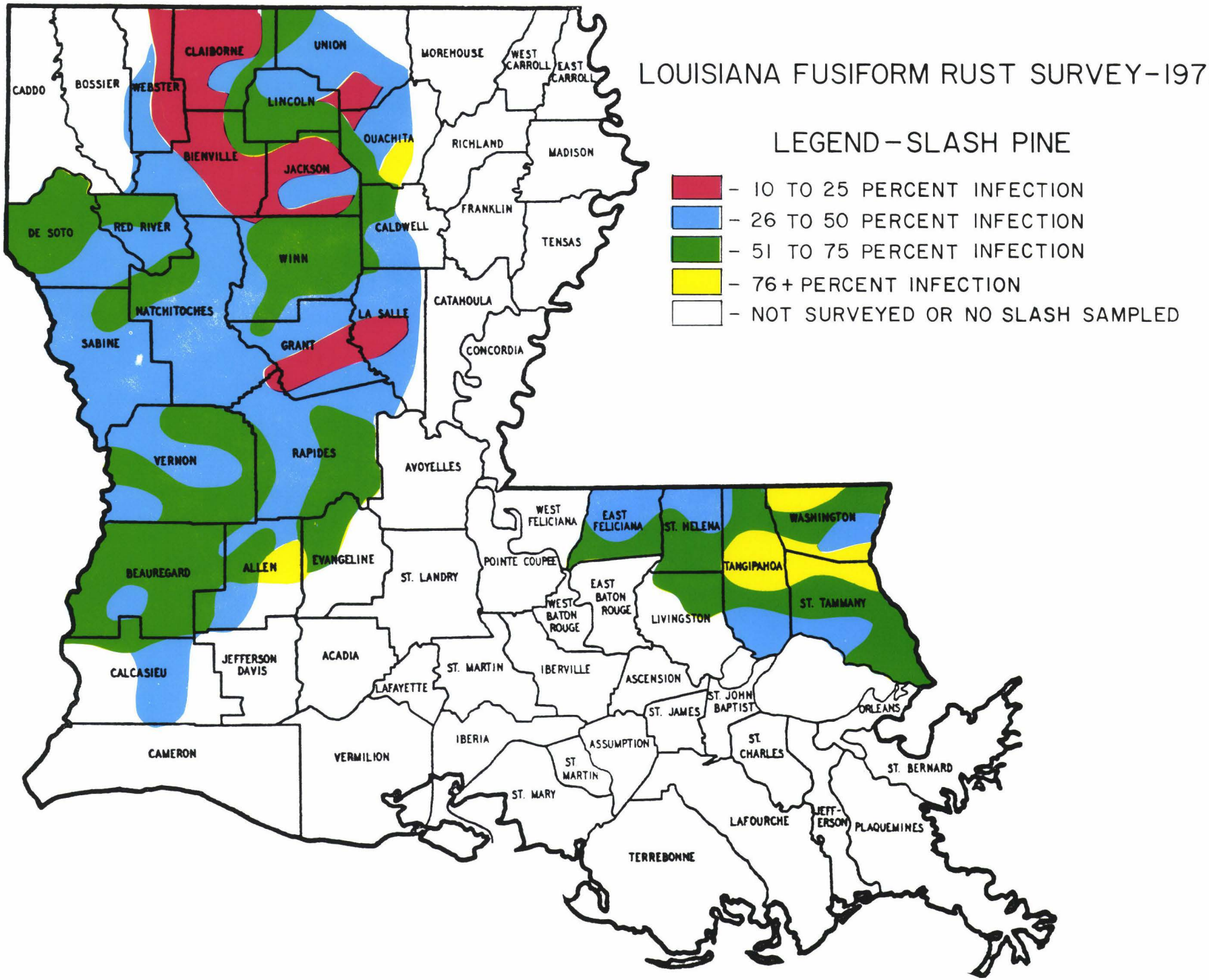
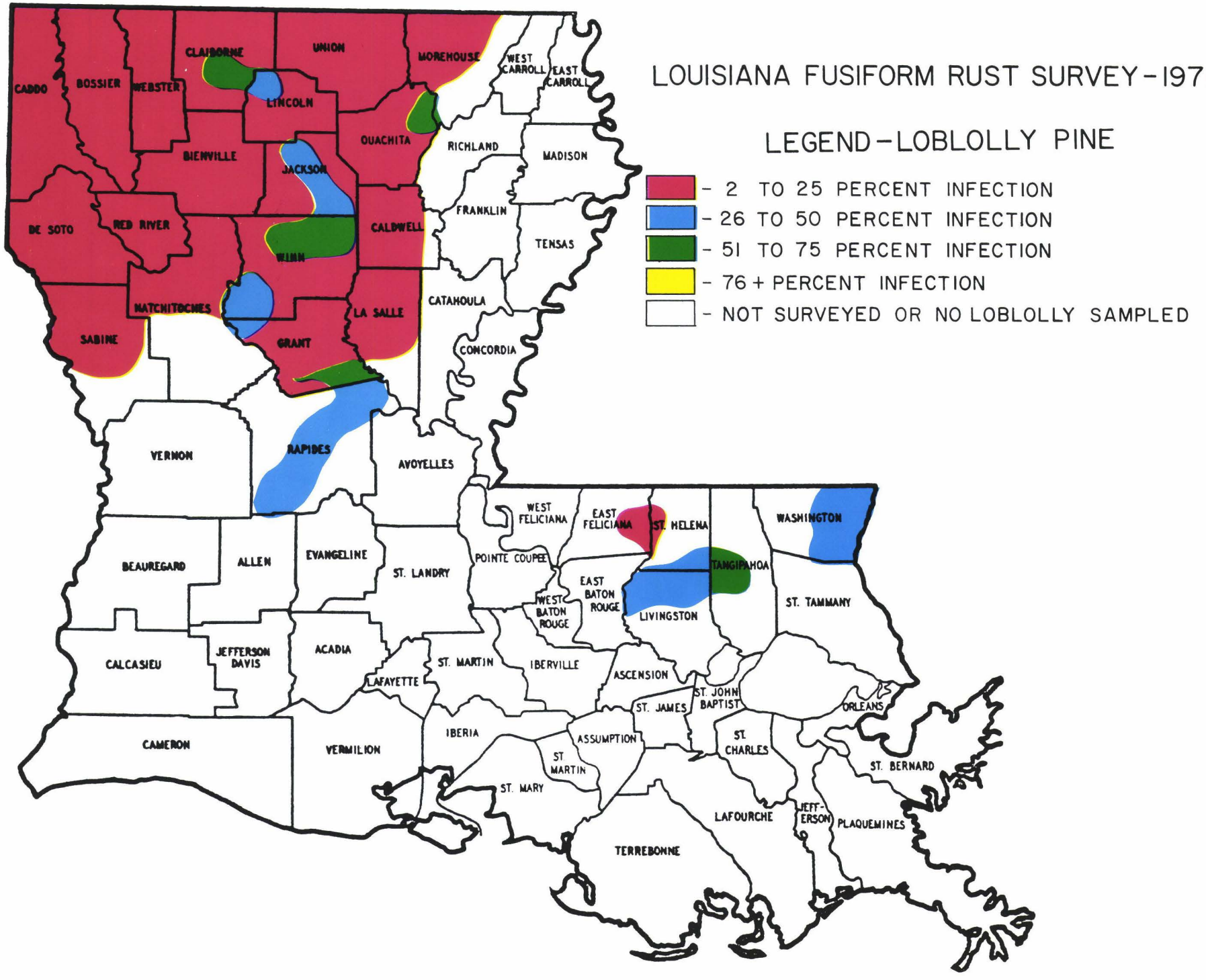
TABLE 1 - LOUISIANA FUSIFORM RUST SURVEY - 1971

DISTRICT	PARISH	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION			
		SLASH		LOBLOLLY	
		Number	Range	Number	Range
1	St. Tammany	7	50-76	0	--
	Tangipahoa	5	38-87	1	59
	Washington	7	45-85	3	26-30
Total		19		4	
2	Allen	9	37-85	0	--
	Evangeline	2	63-68	0	--
Total		11		0	
3	Caldwell	3	28-54	3	12-22
	Grant	5	22-52	7	2-21
	LaSalle	2	23-34	5	15-22
	Winn	5	44-69	6	11-65
Total		15		21	
4	Bossier	0	--	6	6-10
	Bienville	0	--	8	7-14
	Caddo	0	--	5	4-18
	Clairborne	3	10-32	7	7-67
	Webster	4	4-28	3	6-17
Total		7		29	
5	Jackson	4	13-27	7	15-33
	Lincoln	7	37-70	7	6-26
	Morehouse	0	--	3	6-24
	Ouachita	3	65-84	5	12-65
	Union	9	21-60	9	2-24
Total		23		31	
6	DeSoto	4	36-54	10	9-19
	Natchitoches	6	38-55	5	4-14
	Red River	2	44-61	2	12-17
	Sabine	6	27-56	6	3-9
Total		18		23	
7	Beauregard	11	44-71	0	--
	Calcasieu	3	26-62	0	--
	Vernon	9	42-62	0	--
Total		23		0	
8	Rapides	3	71-73	3	33-49
Total		3		3	
10	E. Feleciana	2	43-67	1	18
	Livingston	1	60	2	39-47
	St. Helena	4	46-80	1	46
Total		7		4	
Grand Total		126		115	


LOUISIANA FUSIFORM RUST SURVEY-1971
LEGEND-SLASH PINE
- 10 TO 25 PERCENT INFECTION
- 26 TO 50 PERCENT INFECTION
- 51 TO 75 PERCENT INFECTION
- 76+ PERCENT INFECTION
- NOT SURVEYED OR NO SLASH SAMPLED
CADDO
BOSSIER
WEBSTER
CLAIBORNE
UNION
MOREHOUSE
WEST CARROLL
EAST CARROLL
LINCOLN
OUACHITA
RICHLAND
MADISON
BIENVILLE
JACKSON
FRANKLIN
TENSAS
DE SOTO
RED RIVER
CALDWELL
WINN
CATAHOULA
NATCHITOCHES
LA SALLE
SABINE
GRANT
CONCORDIA
VERNON
RAPIDES
AVOYELLES
WEST FELICIANA
EAST FELICIANA
ST. HELENA
WASHINGTON
BEAUREGARD
ALLEN
EVANGELINE
ST. LANDRY
POINTE COUPEE
TANGIPAHOA
EAST BATON ROUGE
WEST BATON ROUGE
LIVINGSTON
ST. TAMMANY
CALCASIEU
JEFFERSON DAVIS
ACADIA
ST. MARTIN
IBERVILLE
ASCENSION
LAFAYETTE
ST. JOHN BAPTIST
ST. JAMES
ORLEANS
IBERIA
ASSUMPTION
ST. CHARLES
CAMERON
VERMILION
ST. MARTIN
ST. BERNARD
ST. MARY
LAFOURCHE
JEFF-ERSON
PLAQUEMINES
TERREBONNE


LOUISIANA FUSIFORM RUST SURVEY - 1971
LEGEND - LOBLOLLY PINE
- 2 TO 25 PERCENT INFECTION
- 26 TO 50 PERCENT INFECTION
- 51 TO 75 PERCENT INFECTION
- 76 + PERCENT INFECTION
- NOT SURVEYED OR NO LOBLOLLY SAMPLED
CADDO
BOSSIER
WEBSTER
CLAIBORNE
UNION
MOREHOUSE
WEST CARROLL
EAST CARROLL
LINCOLN
OUACHITA
RICHLAND
MADISON
BIENVILLE
JACKSON
FRANKLIN
TENSAS
DE SOTO
RED RIVER
WINN
CALDWELL
CATAHOULA
NATCHITOCHES
LA SALLE
SABINE
GRANT
CONCORDIA
VERNON
RAPIDES
AVOYELLES
WEST FELICIANA
EAST FELICIANA
ST. HELENA
WASHINGTON
BEAUREGARD
ALLEN
EVANGELINE
ST. LANDRY
POINTE COUPEE
TANGIPAHOA
EAST BATON ROUGE
WEST BATON ROUGE
LIVINGSTON
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ST. JOHN BAPTIST
ST. JAMES
ORLEANS
IBERIA
ASSUMPTION
ST. CHARLES
CAMERON
VERMILION
ST. MARTIN
ST. BERNARD
ST. MARY
LAFOURCHE
JEFF-ERSON
PLAQUEMINES
TERREBONNE

APPENDIX 6

SURVEY FOR FUSIFORM RUST IN MISSISSIPPI

A SURVEY FOR FUSIFORM RUST IN MISSISSIPPI

Elmer R. Roth and H. W. Echols 1/

ABSTRACT

A fusiform rust survey was conducted in Mississippi during the first half of 1972. The entire State was grided at ten mile intervals, east-west and north-south. A plantation of slash and/or loblolly was sampled in the eight to twelve year age class that was located at or near the intersection of the grid lines. The survey was accomplished by the ratio estimation statistical survey method using three rows as the sample. Maps showing infection intensity for both slash and loblolly pine were prepared from the field data. Infection rates were very similar for both slash and loblolly. Impact of fusiform as determined by dead and other non-merchantable trees is included.

INTRODUCTION

According to the 1952 Timber Resources Review, fusiform rust of southern pine causes a ten million dollar loss annually in sawtimber and 97 million cubic feet in growing stock. The incidence of rust is intensifying in areas where slash and loblolly pine have been planted on former longleaf pine sites. As the supply of seedlings showing resistance to fusiform rust is limited, it is important that areas of high infection potential are known, so that the resistant seedlings can be planted in these areas and the more susceptible seedlings planted in areas where infection potential is not so great. No attempt has been made to make a southwide survey for fusiform rust since 1939 (2). The University of Florida, Cooperative Tree Improvement Group, has completed a fusiform rust survey in slash pine in plantations of their cooperators in north Florida, south Georgia, and southern South Carolina (1). A survey was also conducted in South Carolina in 1964 whereby two plantations per county were sampled. Recently Yandle and Roth (8) developed a sampling method whereby pine plantations can be sampled by tallying rust infections on as few as three randomly selected rows in a plantation. If present plans materialize, the

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1/ Respectively, Staff Pathologist, State and Private Forestry, Southeastern Area, and Director, Insect and Disease Control, Mississippi Forestry Commission.

Mississippi Forestry Commission will have a limited amount of disease-resistant seedlings available by 1980. Production of disease-resistant seedlings, according to present plans, will increase annually until all nursery seedlings are from disease-resistant orchard trees.

SURVEY METHODS

A survey using the Yandle-Roth method was conducted in Mississippi during the first half of 1972. All of the counties in the State were surveyed, but plantations meeting the species and age requirements were not found in some of the counties in the west central District, which is composed of delta counties. The entire State was grided on county maps, using ten mile square grids with lines running north-south and east-west. In the actual survey, a plantation in the correct age group (eight to twelve years) was selected for sampling where the north-south, east-west lines intersected. One plantation of slash pine and one plantation of loblolly pine were to be sampled at each intersection if available. There were 71 slash and 248 loblolly pine plantations sampled. The plantations sampled were ones in the eight to twelve year age group, closest to where the grid lines crossed and not over five miles from that point. Plantations of less than five acres in area and those that had previously been pruned or thinned were not considered. In general, loblolly pine was present in the northern part of the State and slash pine in the south. After selecting the plantation to be sampled, the rows were quickly counted and the three rows to be sampled were chosen by using a table of random numbers. The selected rows were then sampled, recording whether the trees were healthy, had a stem canker, had a branch canker, had both stem and branch canker, had been killed by fusiform and if the tree was non-merchantable. (Figure 1)

After the data were recorded for each county by State personnel, it was analyzed by personnel of State and Private Forestry, Southeastern Area. The preliminary analysis consisted of determining the percentage of infection for each plantation sampled. Using these percentages, maps were developed for both slash (Figure 2) and loblolly (Figure 3) pine, showing areas of infection as 0 to 25 percent, 26 to 50 percent, 51 to 75 percent and 76 percent plus. Table 1 shows the number of plantations sampled in each county and the range of infection for both slash and loblolly pine for the plantations sampled. Districts NE, NW, WC, and SW were almost devoid of slash pine while districts WC, and SW did not have much loblolly pine in the correct age group.

As percent infected includes both stem and branch cankers, it is the opinion of most management foresters that stands with 50 percent or less infection can be successfully managed for pulpwood, lumber and pole products. Spacing of seedlings would allow for adequate stocking, even though as many as 50 percent were infected. Special consideration should be given to those areas where infection is greater than 50 percent. Foresters should consider planting seedlings that show resistance to fusiform rust in areas of heavy infection.

Field data collection was made by Mississippi Forestry Commission foresters. A training session was held in Jackson for management foresters. The training session was conducted by personnel of the U. S. Forest Service, Southeastern Area, State and Private Forestry.

The Mississippi Forestry Commission foresters did an excellent job in collecting the field data. The survey was completed without unduly interfering with the normal workload of the foresters.

RESULTS AND DISCUSSION

Figures 2 and 3 show areas of infection intensity for both loblolly and slash pine, respectively. Loblolly pine was present in the north and southwest. It was absent in the hardwood belt along the Mississippi River and in the Southeast where slash and longleaf are the predominant species. The absence of a species in this survey does not in fact mean that the species is absent from the area, but that it was not present in the age class required by the survey. Most of the higher infections are in the southern one-third of the State, even here there were very few plantations sampled where the infection rate was greater than 75 percent. In areas where the two species were growing together the infection rates were similar. The highest rates of infection recorded in this survey was 85 percent for slash in Walthall County and 85 percent for loblolly in Adams County.

TABLE 1 - MISSISSIPPI FUSIFORM RUST SURVEY - 1972

DISTRICT	COUNTY	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION			
		SLASH		LOBLOLLY	
		NUMBER	RANGE (percent)	NUMBER	RANGE (percent)
NE	Alcorn	0	--	5	1-4
	Benton	0	--	4	1-2
	Chickasaw	0	--	4	12-31
	Clay	0	--	5	5-47
	Itawamba	1	-25	5	23-63
	Lee	0	--	5	3-16
	Monroe	0	--	8	0-29
	Pontotoc	0	--	4	5-31
	Prentiss	0	--	4	5-17
	Tippah	0	--	5	1-13
	Tishomingo	0	--	3	0-2
	Union	0	--	5	1-19
Total		1		57	
NW	Calhoun	0	--	7	11-34
	Carroll	0	--	7	3-23
	DeSoto	0	--	4	6-9
	Grenada	0	--	2	2-6
	LaFayette	0	--	8	0-8
	Marshall	0	--	8	3-11
	Montgomery	0	--	5	3-7
	Panola	0	--	7	5-19
	Tallahatchie	0	--	3	3-9
	Tate	0	--	3	3-9
	Webster	0	--	3	10-23
	Yalobusha	0	--	4	2-13
Total		0		61	
WC	Bolivar	0	--	0	--
	Coahoma	0	--	0	--
	Holmes	0	--	6	12-39
	Humphreys	0	--	0	--
	Issaquena	0	--	0	--
	Leflore	0	--	0	--
	Quitman	0	--	0	--
	Sharkey	0	--	0	--

TABLE 1 - (Continued)

DISTRICT	COUNTY	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION			
		SLASH		LOBLOLLY	
		NUMBER	RANGE (Percent)	NUMBER	RANGE (percent)
WC	Sunflower	0	--	0	--
	Tunica	0	--	0	--
	Warren	0	--	1	-53
	Washington	0	--	0	--
	Yazoo	0	--	3	20-46
Total		0		10	
EC	Attala	5	29-63	1	-23
	Choctaw	0	--	4	12-46
	Kemper	1	-56	4	19-41
	Lauderdale	0	--	5	24-43
	Leake	2	30-36	4	28-45
	Lowndes	0	--	3	36-51
	Madison	1	-77	-	-8
	Neshuba	1	-70	3	16-33
	Newton	0	--	3	41-62
	Noxubee	0	--	2	26-51
	Oktibbeha	0	--	3	5-8
	Scott	1	-70	5	17-48
	Winston	0	--	4	22-46
Total		11		42	
SC	Clarke	0	--	7	27-72
	Covington	3	39-66	1	-34
	Jasper	0	--	3	52-53
	Jefferson Davis	3	29-40	0	--
	Jones	1	-35	0	--
	Rankin	0	--	4	33-61
	Simpson	1	-52	0	--
	Smith	1	-39	6	18-43
	Wayne	7	8-73	2	31-43
Total		16		23	

TABLE 1 - (Continued)

DISTRICT	COUNTY	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION			
		SLASH		LOBLOLLY	
		NUMBER	RANGE (percent)	NUMBER	RANGE (percent)
SW	Adams	0	--	6	39-85
	Amite	0	--	6	54-75
	Claiborne	0	--	3	31-50
	Copiah	0	--	8	36-74
	Franklin	0	--	5	37-82
	Hinds	1	-52	1	-54
	Jefferson	0	--	6	50-61
	Lawrence	1	-71	4	23-44
	Lincoln	0	--	6	36-68
	Pike	1	-65	2	49-63
	Walthall	3	62-85	0	--
	Wilkinson	0	--	4	44-75
Total		6		51	
SE	Forrest	5	32-67	0	--
	George	4	23-49	0	--
	Greene	4	13-29	0	--
	Hancock	3	52-69	2	24-31
	Harrison	1	-58	0	--
	Jackson	1	-17	0	--
	Lamar	3	47-61	1	-34
	Marion	0	--	0	--
	Pearl River	7	68-84	0	--
	Perry	6	30-75	1	-76
	Stone	3	6-78	0	--
Total		37		4	
Grand Total		71	43-58	248	21-38

FUSIFORM RUST IMPACT

The percentages of healthy, stem cankered, branch cankered, and non-merchantable, fusiform rust-killed trees are presented in Table 2. The tree percent is more than 100 because of the combination of infection categories. A total of 51,560 loblolly and 18,548 slash pines were used in this sample. Thirty-three percent of all the loblolly pines were diseased while forty-seven percent slash pines had visible infections. A higher percentage of stem cankers was found on slash pines than on loblolly but the incidence of branch cankers was higher than stem cankers on both species. Three and seven percent of 8-12 year old loblolly and slash pines, respectively, were dead or non-merchantable due to fusiform rust. Percentages of dead or non-merchantable pines were considerably higher in some local areas of the State, especially in the Southwest and East Central Districts. Although it appears that fusiform rust is not causing severe losses in this age group of pines for the whole State of Mississippi, losses in other age groups may well exceed those found here.

Table 2. Impact of Fusiform Rust on 8-12 Year Loblolly and Slash Pine Plantations.

	LOBLOLLY (Percent of trees)*				SLASH (Percent of trees)*			
District	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead
Northeast	88	5	8	1	75	10	17	1
West Central	73	12	18	3	--	--	--	--
North West	91	5	5	1	--	--	--	--
South West	45	23	44	2	36	34	47	5
East Central	65	18	17	6	47	26	24	13
South East	58	6	34	4	45	17	43	6
South Central	52	22	33	7	60	18	27	5
State Average	67	13	23	3	53	21	32	7

*Percent of trees do not add up to 100 percent because of category combinations.

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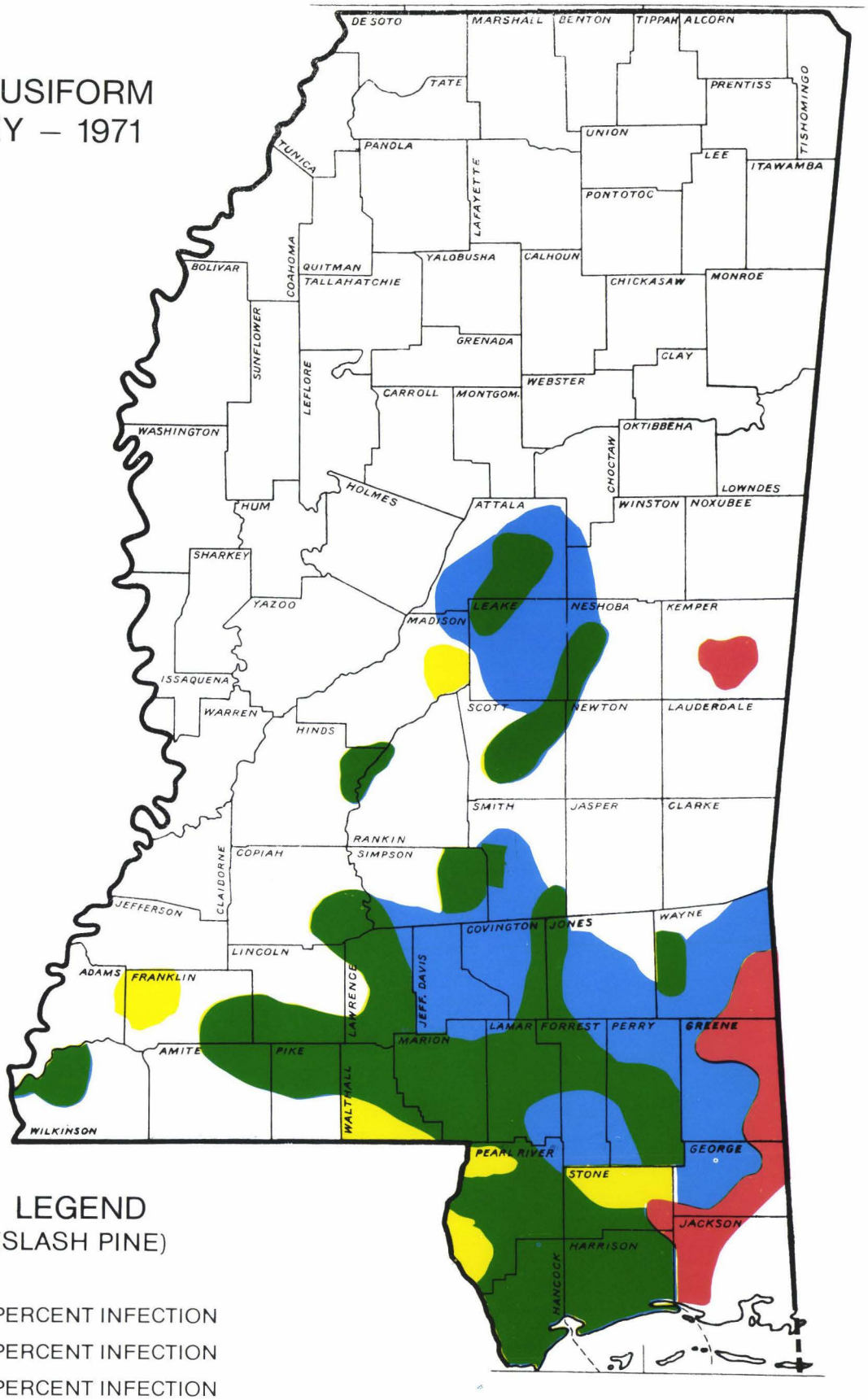
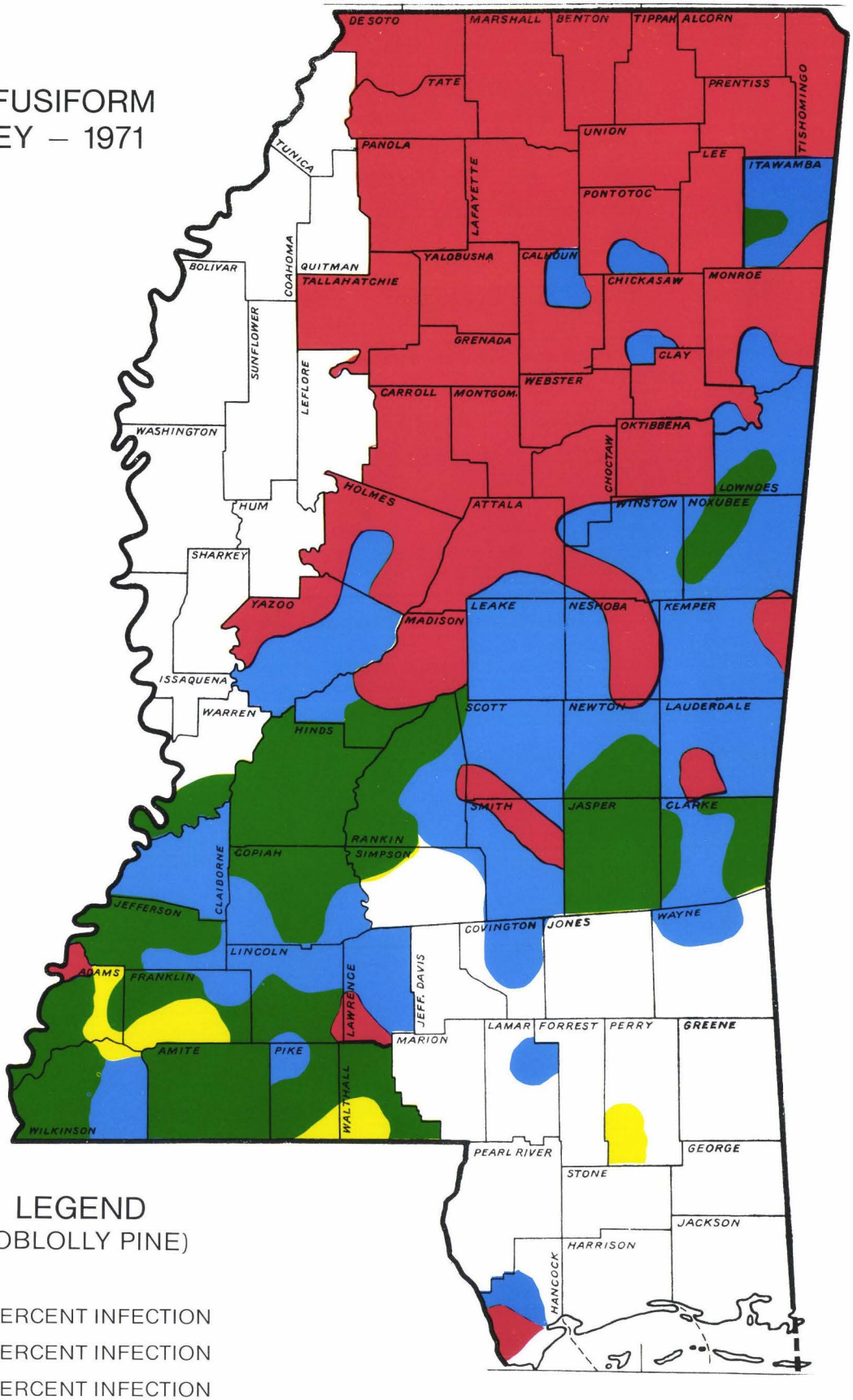
MISSISSIPPI FUSIFORM RUST SURVEY – 1971



LEGEND
(SLASH PINE)

- — 0 TO 25 PERCENT INFECTION
- — 26 TO 50 PERCENT INFECTION
- — 51 TO 75 PERCENT INFECTION
- — 76+ PERCENT INFECTION
- — NO SLASH SAMPLED

MISSISSIPPI FUSIFORM RUST SURVEY – 1971



LEGEND
(LOBLOLLY PINE)

- — 0 TO 25 PERCENT INFECTION
- — 26 TO 50 PERCENT INFECTION
- — 51 TO 75 PERCENT INFECTION
- — 76+ PERCENT INFECTION
- — NO SLASH LOBLOLLY SAMPLED

APPENDIX 7

SURVEY FOR FUSIFORM RUST IN NORTH CAROLINA

A SURVEY FOR FUSIFORM RUST IN NORTH CAROLINA

William R. Phelps [1/] and Coleman Doggett [2/]

ABSTRACT

A fusiform rust incidence survey was conducted in North Carolina during 1972-73. The entire state, except the western extremities, was grided at ten mile intervals, east-west and north-south. A plantation of slash and/or loblolly was sampled in the eight to twelve year age class that was located at or near the intersection of the grid lines. The survey was accomplished by the ratio estimation statistical survey method using three rows as the sample. Maps showing infection intensity for both slash and loblolly were prepared from the field data. Infection rates ranged from 5 to 72 percent for slash pine and 0 to 81 percent for loblolly pine. Impact of fusiform as determined by percent of infected and dead and other non-merchantable trees was quite low.

INTRODUCTION

According to the 1952 Timber Resources Review, fusiform rust of southern pine causes an estimated annual loss of 281 million board feet of sawtimber and 97 million cubic feet of growing stock. This amounts to an annual stumpage loss of $10 million. The incidence of rust is intensifying in some areas where slash and loblolly pine have been planted on former longleaf pine sites. As the supply of seedlings showing resistance to fusiform rust is limited, it is important that areas of high infection potential are known, so that the resistant seedlings can be planted in these areas and the more susceptible seedlings planted in areas where infection potential is not so great. No attempt has been made to make a southwide survey for fusiform rust since 1939 (2). The University of Florida, Cooperative Tree Improvement Group, has completed a fusiform rust survey in slash pine in plantations of their cooperators in north Florida, south Georgia, and southern South Carolina (1). A paper by Schmidt, Goddard and Hollis (10) now in

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1/ Area Staff Pathologist, State & Private Forestry, Southeastern Area, U.S. Forest Service.

2/ Pest Control Staff Forester, North Carolina Forest Service.

press gives an excellent account of the incidence and distribution of fusiform rust in slash pine plantations in Florida and Georgia. Recent statewide rust surveys (1971-1973) have been completed in Florida (4), Louisiana (5), South Carolina (6), Georgia (7), Arkansas (8), Mississippi (9), and Alabama (3). A survey was also conducted in South Carolina in 1964 whereby two plantations per county were sampled. Yandle and Roth (8) developed a sampling method whereby pine plantations can be sampled by tallying rust infections on as few as three randomly selected rows in a plantation.

SURVEY METHODS

A survey using the Yandle - Roth method was conducted by pest management specialists in North Carolina during 1972-1973. All the counties except the ones in the western extremities were surveyed, but plantations meeting the species and age requirements were not found in some of the counties. County maps were grided, using ten mile square grids with lines running north-south and east-west. In the actual survey, a plantation in the correct age group (eight to twelve years) was selected for sampling where the north-south, east-west lines intersected. One plantation of slash pine and one plantation of loblolly pine were to be sampled at each intersection if available. There were 76 slash and 282 loblolly pine plantations sampled. The plantations sampled were ones in the eight to twelve year age group, closest to where the grid lines crossed and not over five miles from that point. Plantations of less than five acres in area and those that had previously been pruned or thinned were not considered. In general, loblolly pine was generally present throughout the sampled area while slash pine was found in the eastern and southern part.

After selecting the plantation to be sampled, the rows were quickly counted and the three rows to be sampled were chosen by using a table of random numbers. The selected rows were then sampled, recording whether the trees were healthy, had a stem canker, had a branch canker, had both stam and branch canker, had been killed by fusiform, and if the tree was non-merchantable due to fusiform rust (Figure 1).

After the data were recorded for each county by State personnel, it was analyzed by personnel of State and Private Forestry, Southeastern Area. The preliminary analysis consisted of determining the percentage of infection for each plantation sampled. Using these percentages, maps were developed for both slash (Figure 2) and

loblolly (Figure 3) pine, showing areas of infection as 0 to 25 percent, 26 to 50 percent, 51 to 75 percent and 76 percent plus. Table 1 shows the number of plantations sampled in each county and the range of infection for both slash and loblolly pine for the plantations sampled. Loblolly pine has not been extensively planted in the mountain portion of the state so this area was not surveyed. The only counties with sufficient slash pine plantations, meeting sampling criteria, were located in the southeastern and south central portion of the state. No other counties were sampled for rust incidence on slash.

It is the opinion of most management foresters that stands with 50 percent or less stem infection can be successfully managed for pulpwood, lumber or other timber products. All counties in North Carolina had average stem infection below 25% for loblolly and 31 percent for slash (1 and 2). Recent increased seedling and planting costs, however, have caused a reduction in numbers of seedlings planted per acre. Each individual tree, therefore, becomes much more significant. Consequently, forest managers should carefully evaluate planting practices where fusiform rust incidence is high. In high infection areas managers should consider planting higher numbers of seedlings per acre, planting genetically rust resistant seedlings, or planting alternative species such as longleaf, shortleaf, Virginia and white pine.

Field data collection was made by North Carolina Forest Service pest control specialists Barron, Doggett, Maxwell, Taylor, and Webb. In addition staff, district and county personnel gave considerable help in plantation location and data collection. A training program was held in Morganton, North Carolina, by personnel from the U.S. Forest Service, Southeastern Area, State and Private Forestry to train personnel in data collection.

RESULTS AND DISCUSSION

Figures 2 and 3 show areas of infection intensity for both loblolly and slash pine respectively. The absence of a species in this survey does not in fact mean that the species is absent from the area, but that it was not present in the age class required by the survey. Fusiform rust is not as severe in North Carolina as it is in most of the southeastern states. This was especially so for loblolly pine. The most infection for loblolly was found in the south central counties. Infection incidence of slash pine was very similar in all districts where it was growing and surveyed. As was found in other southeastern states, slash pine had more rust infection than loblolly pine. The highest incidence rates recorded in this survey were 81 percent for

loblolly pine in Anson County and 72 percent for slash pine in Duplin County. The range of infection was from 0 to 81 percent for loblolly pine and from 5 to 72 percent for slash. Table 1 shows the incidence of rust by counties.

FUSIFORM RUST IMPACT

The percentages of healthy, stem cankered, branch cankered, and non-merchantable fusiform rust-killed trees are presented in Table 2. The total tree percent is more than 100 because of the combination of infection categories. A total of 61,362 loblolly and 15,940 slash pines were used in this sample. Seventy-nine percent of all the loblolly pines were healthy while sixty-five percent slash pines did not have any infection. Only 9 percent of the loblolly had stem cankers while there were 16 percent in slash pines. Two percent of the trees sampled in both species were dead or non-merchantable due to the rust. Table 2 shows the impact of rust on 8-12 year loblolly and slash pine plantations by counties. Table 3 gives the data by North Carolina Forest Service districts. The largest amount of dead and non-merchantable trees were found in counties in south central North Carolina. These impact results are among the lowest of all the states surveyed in the southeast. Although it appears that fusiform rust is not causing severe losses in this age group of pines for the whole state of North Carolina, losses in other age groups may well exceed those found in this survey. In some localized areas and in some plantations rust may be a limiting factor in growing a productive timber crop.

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TABLE 1 - NORTH CAROLINA FUSIFORM RUST SURVEY - 1972-73

COUNTY	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION			
	LOBLOLLY		SLASH	
	Number	Range (percent)	Number	Range (percent)
Alamance	5	0-4	0	--
Anson	5	25-81	0	--
Beaufort	5	18-50	0	--
Bertie	8	11-46	0	--
Bladen	10	12-47	10	12-70
Brunswick	7	11-45	8	24-55
Cabarrus	5	8-17	0	--
Columbus	8	23-66	6	28-48
Camden	1	6	0	--
Carteret	1	27	0	--
Caswell	2	0-2	0	--
Catawba	4	0-2	0	--
Chatham	6	4-13	0	--
Chowan	4	3-24	0	--
Craven	4	26-58	0	--
Cumberland	5	22-42	5	5-49
Davie	2	0-17	0	--
Davidson	4	3-6	0	--
Duplin	7	31-75	6	55-72
Durham	4	4-41	0	--
Edgecombe	4	15-28	0	--
Forsyth	1	0	0	--
Franklin	5	2-22	0	--
Gaston	4	0-11	0	--
Gates	2	26-34	0	--
Granville	7	1-7	0	--
Greene	2	24-41	0	--
Guilford	5	1-5	0	--
Halifax	9	6-34	0	--
Harnett	3	11-40	4	8-43
Hertford	4	17-33	0	--
Hoke	4	17-37	2	33-42
Hyde	3	2-7	0	--
Iredell	4	0-11	0	--
Johnston	4	21-36	0	--
Jones	4	34-48	0	--

TABLE 1 - (Continued)

COUNTY	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION			
	LOBLOLLY		SLASH	
	Number	Range (percent)	Number	Range (percent)
Lee	2	13-16	0	--
Lenoir	1	70	0	--
Lincoln	3	5-26	0	--
Martin	2	10-28	0	--
Mecklenburg	5	5-19	0	--
Moore	6	8-13	4	13-39
Montgomery	7	2-37	1	58
Nash	4	19-29	0	--
New Hanover	1	10	1	27
Northampton	5	11-43	0	--
Onslow	1	29	4	13-57
Orange	4	2-10	0	--
Pasquotank	4	4-15	0	--
Pender	7	25-57	7	24-56
Perquimans	3	13-25	0	--
Person	2	0	0	--
Pitt	2	30-43	0	--
Randolph	5	9-19	0	--
Richmond	4	15-22	3	21-43
Robeson	5	29-52	4	21-42
Rockingham	2	0-3	0	--
Rowan	3	13-17	0	--
Sampson	8	23-58	7	32-59
Scotland	2	11-44	2	52
Stanly	3	4-22	0	--
Stokes	2	1-5	0	--
Tyrrell	2	11-23	0	--
Union	5	16-35	0	--
Vance	3	1-9	0	--
Wake	6	12-38	0	--
Warren	4	3-8	0	--
Washington	3	11-29	0	--
Wayne	3	29-35	2	16-50
Wilson	2	36-43	0	--
Total	282	12-29	76	22-51

TABLE 2. Impact of Fusiform Rust on 8-12 Year Loblolly and Slash Pine Plantations in North Carolina

	LOBLOLLY (Percent of trees)*				SLASH (Percent of trees)*			
COUNTY	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead
Alamance	98	0	2	0	--	--	--	--
Anson	56	8	33	8	--	--	--	--
Beaufort	68	11	26	1	--	--	--	--
Bertie	78	10	18	2	--	--	--	--
Bladen	58	16	28	1	64	20	35	2
Brunswick	72	14	23	1	62	14	32	3
Cabarrus	89	2	8	1	--	--	--	--
Columbus	62	18	30	4	61	16	36	1
Camden	91	2	4	2	--	--	--	--
Carteret	73	17	24	1	--	--	--	--
Caswell	99	0	1	0	--	--	--	--
Catawba	99	0	1	0	--	--	--	--
Chatham	91	4	6	0	--	--	--	--
Chowan	84	6	14	0	--	--	--	--
Craven	62	16	34	2	--	--	--	--
Cumberland	71	13	24	3	75	12	22	2
Davie	92	0	8	0	--	--	--	--

TABLE 2. Impact of Fusiform Rust on 8-12 Year Loblolly and Slash Pine Plantations in North Carolina (Cont.)

COUNTY	LOBLOLLY (Percent of trees)*				SLASH (Percent of trees)*			
	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead
Davidson	96	1	2	1	--	--	--	--
Duplin	51	24	40	5	37	31	58	4
Durham	79	7	12	2	--	--	--	--
Edgecombe	79	8	20	0	--	--	--	--
Forsyth	100	0	0	0	--	--	--	--
Franklin	88	5	10	0	--	--	--	--
Gaston	90	2	8	0	--	--	--	--
Gates	73	8	24	1	--	--	--	--
Granville	96	1	3	0	--	--	--	--
Greene	68	10	27	1	--	--	--	--
Guilford	93	0	3	0	--	--	--	--
Halifax	81	5	16	0	--	--	--	--
Harnett	67	16	26	5	80	10	18	0
Hertford	75	8	20	2	--	--	--	--
Hoke	72	12	25	2	60	27	6	5
Hyde	96	1	3	0	--	--	--	--
Iredell	95	1	4	0	--	--	--	--
Johnston	70	14	25	3	--	--	--	--

TABLE 2. Impact of Fusiform Rust on 8-12 Year Loblolly and Slash Pine Plantations in North Carolina (Cont.)

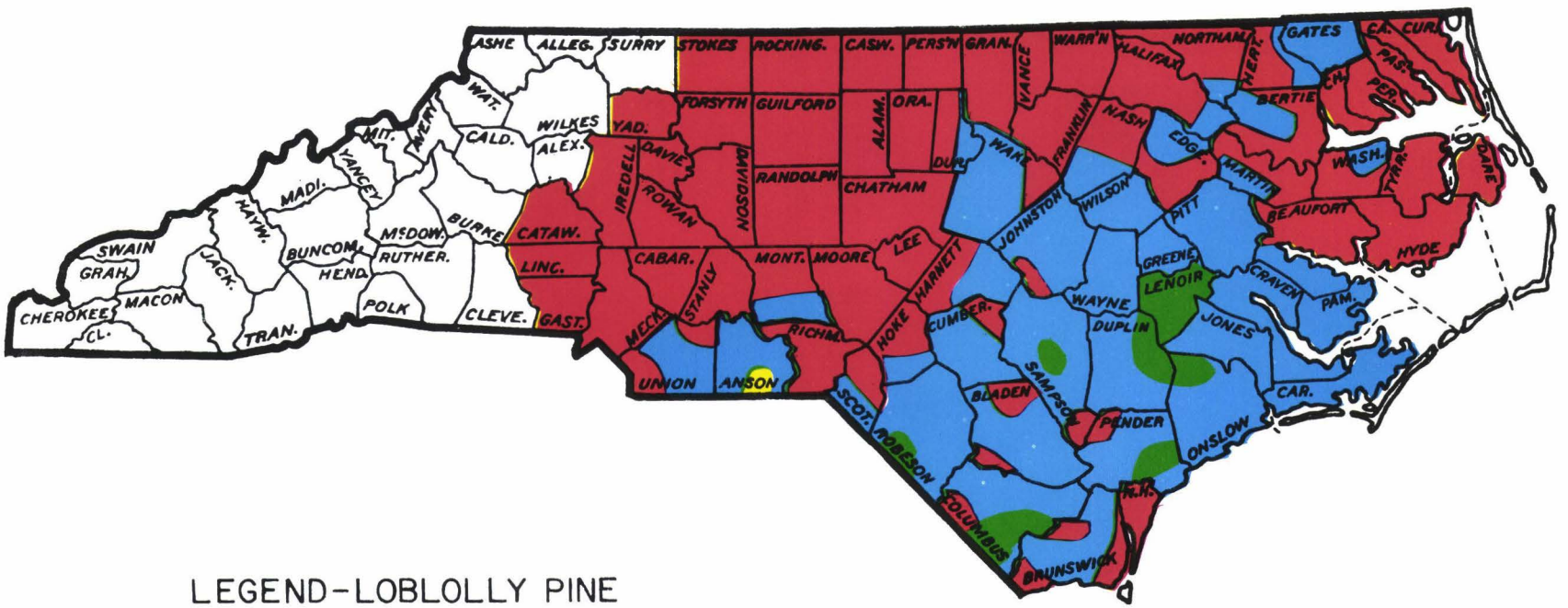
COUNTY	LOBLOLLY (Percent of trees)*				SLASH (Percent of trees)*			
	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead
Jones	61	10	17	3	--	--	--	--
Lee	86	5	12	1	--	--	--	--
Lenoir	30	24	63	3	--	--	--	--
Lincoln	85	1	14	0	--	--	--	--
Martin	80	9	16	1	--	--	--	--
Mecklenburg	88	1	11	1	--	--	--	--
Moore	89	4	10	0	77	12	19	1
Montgomery	82	5	11	4	59	3	43	12
Nash	73	7	21	2	--	--	--	--
New Hanover	87	6	10	1	73	12	24	2
Northampton	83	6	13	1	--	--	--	--
Onslow	71	16	26	0	66	15	28	2
Orange	93	2	6	0	--	--	--	--
Pasquotank	91	5	7	0	--	--	--	--
Pender	62	19	24	2	55	16	36	2
Perquimans	80	7	17	0	--	--	--	--
Person	100	0	0	0	--	--	--	--
Pitt	66	12	29	3	--	--	--	--

TABLE 2. Impact of Fusiform Rust on 8-12 Year Loblolly and Slash Pine Plantations in North Carolina (Cont.)

COUNTY	LOBLOLLY (Percent of trees)*				SLASH (Percent of trees)*			
	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead	Healthy	Stem Cankers	Branch Cankers	Non-merchantable & dead
Randolph	88	2	9	0	--	--	--	--
Richmond	83	8	15	1	68	18	29	2
Robeson	64	14	30	4	69	15	28	1
Rockingham	99	0	1	0	--	--	--	--
Rowan	85	1	11	0	--	--	--	--
Sampson	59	24	38	4	52	26	40	6
Scotland	83	8	14	1	48	24	50	0
Stanly	84	5	13	0	--	--	--	--
Stokes	97	0	3	0	--	--	--	--
Tyrrell	76	6	16	0	--	--	--	--
Union	71	3	23	4	--	--	--	--
Vance	96	1	3	1	--	--	--	--
Wake	74	12	24	1	--	--	--	--
Warren	95	1	4	0	--	--	--	--
Washington	71	11	17	1	--	--	--	--
Wayne	69	10	27	2	69	14	26	2
Wilson	62	18	33	0	--	--	--	--
Grand Average	79	9	17	2	65	16	30	2

*Percent of trees do not add up to 100 percent because of category combinations.

NORTH CAROLINA
FUSIFORM RUST SURVEY-1973

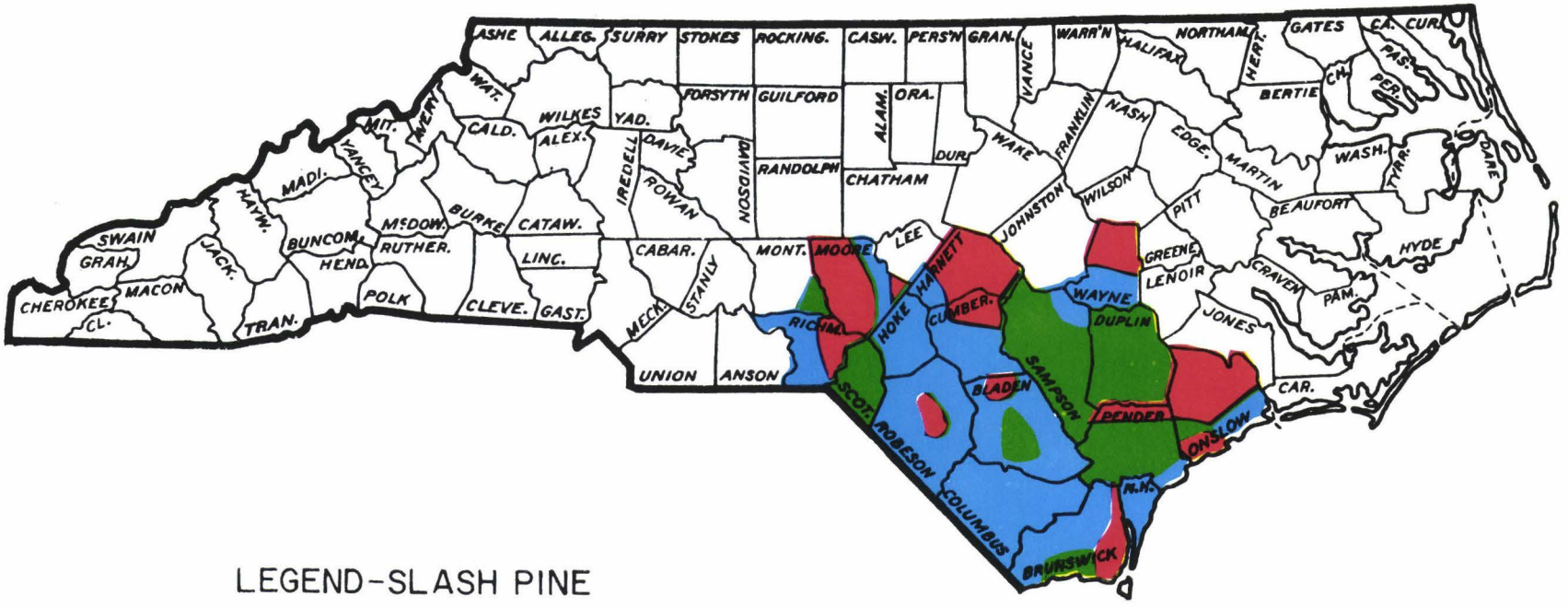


LEGEND-LOBLOLLY PINE

- – 0 TO 25 PERCENT INFECTION
- – 26 TO 50 PERCENT INFECTION
- – 51 TO 75 PERCENT INFECTION
- – 76 + PERCENT INFECTION
- – NOT SURVEYED OR NO LOBLOLLY SAMPLED

FIGURE 2

NORTH CAROLINA
FUSIFORM RUST SURVEY - 1973



LEGEND - SLASH PINE

- 0 TO 25 PERCENT INFECTION
- 26 TO 50 PERCENT INFECTION
- 51 TO 75 PERCENT INFECTION
- 76 + PERCENT INFECTION
- NOT SURVEYED OR NO SLASH SAMPLED

FIGURE 3

APPENDIX 8

SURVEY FOR FUSIFORM RUST IN SOUTH CAROLINA

A SURVEY FOR FUSIFORM RUST IN SOUTH CAROLINA

Elmer R. Roth and John E. Graham [1/]

ABSTRACT

A fusiform rust survey was conducted in South Carolina during August and September, 1971. The entire state was grided at 10 mile intervals, north-south and east-west. A plantation of slash and/or loblolly pine was sampled in the 8-12 year age class that was located at or near the intersection of the grid lines. The survey was accomplished by the ratio estimation statistical method using only three rows as the sample. Maps showing infection intensity for both slash and loblolly pine were prepared from the field data. Counties in the northwestern part of the state lacked slash pine plantations of the correct age or insufficient numbers to sample. Generally speaking, slash pine showed a slightly higher infection rate than did loblolly pine.

INTRODUCTION

According to the 1952 Timber Resources Review, fusiform rust of southern pines in the South cause more than a ten million dollar loss annually in sawtimber and 97 million cubic feet in growing stock. The incidence of rust is intensifying in areas where slash and loblolly pine have been planted on former longleaf sites. As the supply of seedlings showing resistance to fusiform rust is limited, it is important that areas of high infection potential are known, so that the resistant seedlings can be planted on these areas and the more susceptible seedlings planted on areas where the potential is not so great. The South Carolina State Commission of Forestry will have highly disease resistant seedlings available in about 10 years. Annual production according to current plans will be 1 to 1 1/2 million seedlings. No attempt has been made to make a southwide survey for fusiform rust since 1939 (2). The University of Florida Cooperative Tree Improvement Group, has completed a fusiform rust survey in

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1/ Respectively, Staff Pathologist, State and Private Forestry, Southeastern Area; and Forest Management Assistant, South Carolina State Commission of Forestry.

slash pine in plantations of their cooperators in north Florida, south Georgia, and southern South Carolina (1). A survey was also conducted in South Carolina in 1964 whereby two plantations per county were sampled. Recently Yandle and Roth (4) developed a sampling method whereby pine plantations can be sampled by tallying infection on as few as three randomly selected rows in a plantation. In this method both stem and branch cankers are recorded.

SURVEY METHODS

A survey using the above method was conducted in South Carolina during August and September, 1971. All of the counties in the state were laid off on county maps using 10 mile square grids with lines running east-west and north-south. In the actual survey a plantation in the correct age group (8-12 years) was selected for sampling where the north-south, east-west lines intersected. The work plan called for one plantation of slash pine and one plantation of loblolly pine to be sampled at or near each intersection if available. There were 179 slash and 206 loblolly pine plantations sampled. The plantations sampled were ones in the correct age group, closest to where the grid lines crossed and not over five miles from that point. Plantations of less than five acres in area, and those which had previously been pruned or thinned were not considered.

After selecting the plantation to be sampled, the rows were quickly counted and the three rows to be sampled were chosen by using a table of random numbers. The selected rows were then sampled recording whether the trees were healthy, had a stem canker, had a branch canker, had both stem and branch cankers or had been killed by fusiform (Figure 1).

After the data was recorded for each county by State personnel, it was analyzed by personnel of State and Private Forestry, Southeastern Area. The preliminary analysis consisted of determining the percentage of infection for each plantation sampled. (Plantations of both slash and loblolly were not always available near the points where the grid lines intersected.) Using these percentages of infection, maps were developed for both loblolly (Figure 2) and slash (Figure 3) pines showing areas of infection as 0 to 25 percent, 26 to 50 percent, 51 to 75 percent and 76 percent plus. Table One shows the number of plantations sampled in each county and the range of infection for both slash

and loblolly pine for the plantations sampled. Districts Four and Six were almost devoid of slash pine plantations in the correct age groups. These two districts are largely outside of the range in which slash pine is recommended for planting.

As percent infected includes both stem and branch cankers, it is the opinion of most management foresters that stands with 50 percent or less infection can be successfully managed for pulpwood, lumber and pole products. Spacing of seedlings, especially in the past, would allow for adequate stocking even though as many as 50 percent were infected. Special consideration should be given to those areas where infection is greater than 50 percent. In areas of heavy infection, foresters should consider planting seedlings that show resistance to fusiform rust.

Physical completion of the survey was accomplished by South Carolina State Commission of Forestry foresters. A total of six training sessions were conducted in the state for district and county foresters by personnel of the U.S. Forest Service, Southeastern Area, State and Private Forestry. These training sessions were held at Spartanburg, Newberry, Florence, Camden, Walterboro, and Orangeburg. South Carolina State Commission of Forestry management foresters attended the training sessions.

The South Carolina State Commission of Forestry did an excellent and efficient job in collecting the data. The survey was completed in the alloted time without unduly interfering with the normal workload.

RESULTS AND DISCUSSION

The maps (Figure 2 loblolly and Figure 3 slash) show areas of infection intensity for both slash and loblolly pine. Loblolly pine was found in most of the counties while slash pine was almost absent in Districts Four and Six. Where the two species were found in the same general area, slash pine was usually more heavily infected although the most heavily infected plantation sampled was loblolly pine in Florence County. (Compare maps, Figures 2 and 3 and range of infection in Table One.) Infection rates were generally above 50 percent for both species in all Districts except District Six. This is not to infer that all plantations sampled were more than 50 percent infected. It will be noted by examining the maps that an occasional plantation was

sampled where the infection was substantially lower than that of the surrounding plantations. It is not known if these isolated areas represent a real difference for the area in susceptibility, are disease escaping areas, or represent areas where some resistant progeny were planted. In general it can be said that areas of high infection potential for both slash and loblolly pine are common in about three fourths of the state.

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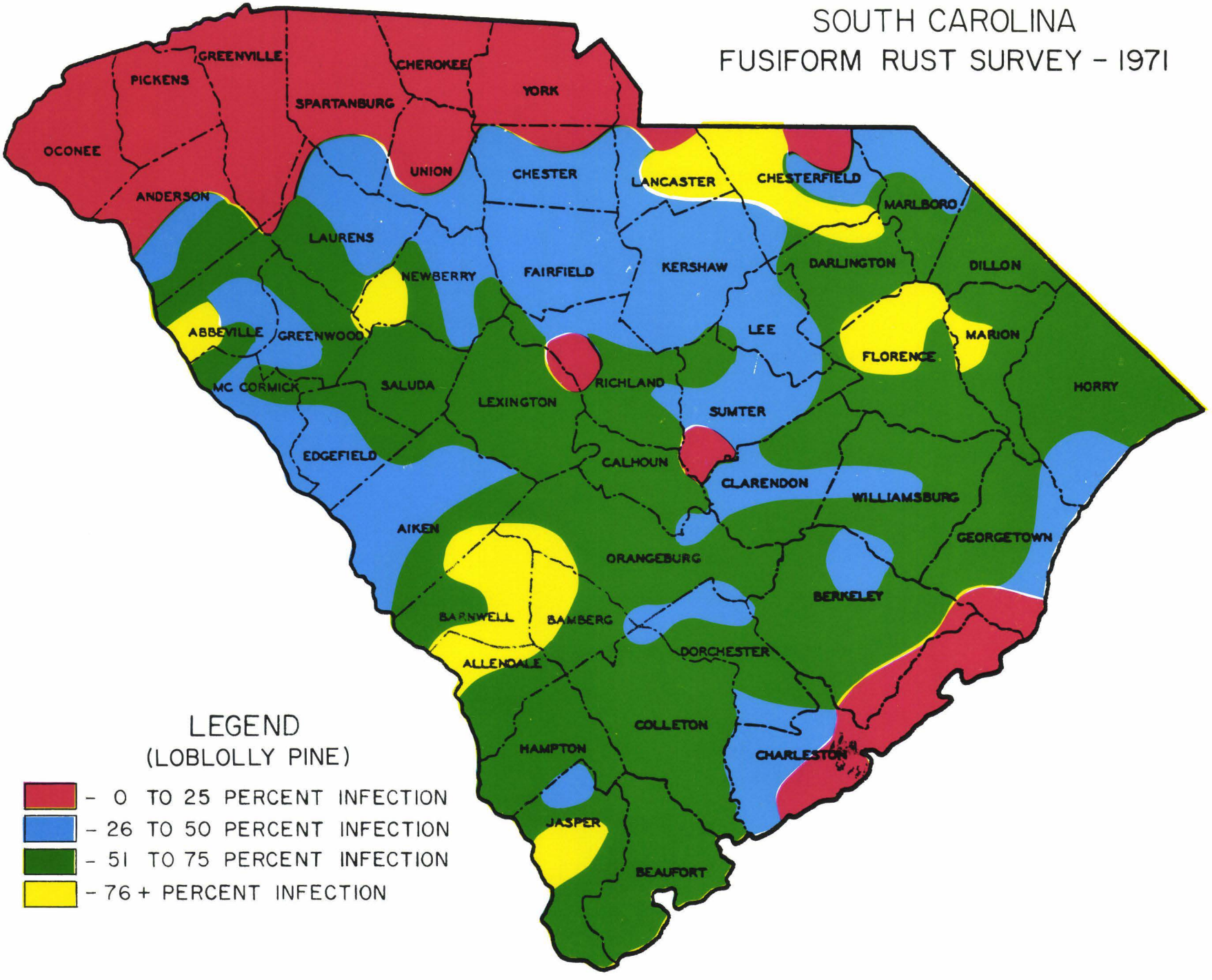
TABLE 1 - SOUTH CAROLINA FUSIFORM RUST SURVEY - 1971

DISTRICT	COUNTY	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION			
		SLASH		LOBLOLLY	
		Number	Range (Percent)	Number	Range (Percent)
1	Chesterfield	10	16-76	3	24-80
	Kershaw	7	22-60	4	30-45
	Lancaster	1	71	5	8-77
	Lee	4	38-56	1	42
	Richland	4	46-79	5	18-57
	Sumter	5	35-67	6	19-61
Total		31		24	
2	Darlington	6	35-83	5	52-83
	Dillon	3	50-53	1	56
	Florence	7	62-87	6	58-95
	Horry	9	22-74	1	50
	Marion	6	49-73	3	54-79
	Marlboro	4	29-59	4	36-60
Total		35		20	
3	Berkeley	5	50-80	7	21-68
	Clarendon	6	68-74	5	43-69
	Georgetown	8	16-77	2	19-53
	Williamsburg	7	47-71	8	39-63
Total		26		22	
4	Abbeville	--	--	6	40-78
	Chester	--	--	4	30-41
	Edgefield	--	--	7	27-71
	Fairfield	1	56	8	29-44
	Greenwood	--	--	5	39-61
	Laurens	--	--	7	42-60
	McCormick	--	--	3	34-59
	Newberry	--	--	7	27-83
	Saluda	--	--	4	52-60
Total		1		51	

TABLE 1 - (Continued)

DISTRICT	COUNTY	NUMBER OF PLANTATIONS SAMPLED AND RANGE OF INFECTION			
		SLASH		LOBLOLLY	
		Number	Range (Percent)	Number	Range (Percent)
5	Aiken	12	50-91	2	40-45
	Allendale	5	77-86	1	83
	Bamberg	3	73-86	2	71-80
	Barnwell	4	75-68	3	69-90
	Calhoun	3	68-76	1	73
	Lexington	7	38-77	3	63-64
	Orangeburg	12	40-81	5	37-66
Total		46		17	
6	Anderson	--	--	7	24-71
	Cherokee	--	--	4	7-13
	Greenville	--	--	8	4-14
	Oconee	--	--	5	4-12
	Pickens	--	--	5	4-22
	Spartanburg	--	--	8	4-38
	Union	--	--	5	3-28
	York	--	--	7	1-18
Total				49	
7	Beaufort	5	35-82	1	62
	Charleston	6	34-65	4	10-49
	Colleton	7	49-88	5	54-75
	Dorchester	7	56-79	6	40-68
	Hampton	7	82-87	2	58-67
	Jasper	8	25-93	5	46-84
Total		40		23	
Grand Total		179	47-75	206	36-59

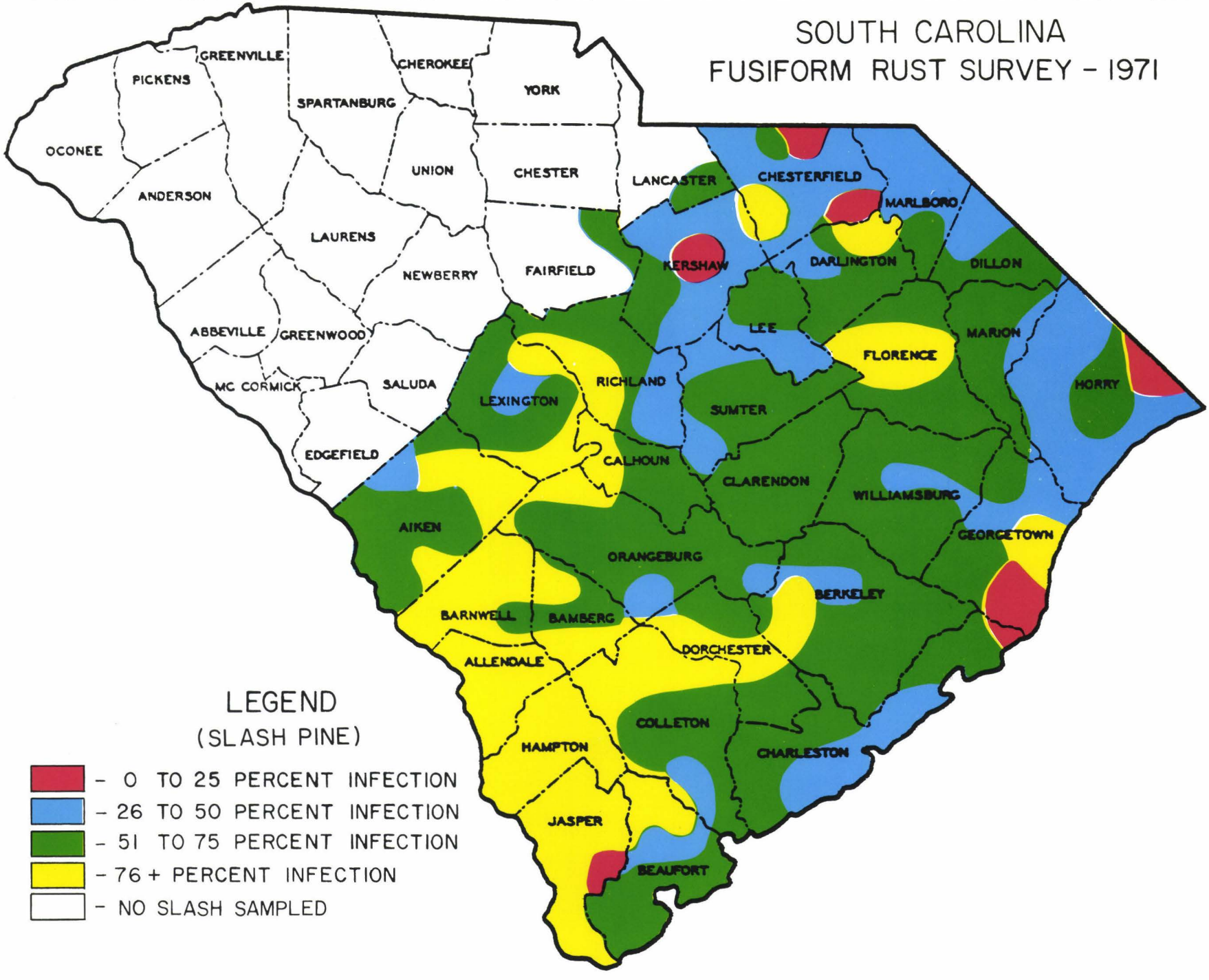
SOUTH CAROLINA
FUSIFORM RUST SURVEY - 1971



LEGEND
(LOBLOLLY PINE)

- 0 TO 25 PERCENT INFECTION
- 26 TO 50 PERCENT INFECTION
- 51 TO 75 PERCENT INFECTION
- 76 + PERCENT INFECTION

SOUTH CAROLINA
FUSIFORM RUST SURVEY - 1971



LEGEND
(SLASH PINE)

- 0 TO 25 PERCENT INFECTION
- 26 TO 50 PERCENT INFECTION
- 51 TO 75 PERCENT INFECTION
- 76 + PERCENT INFECTION
- NO SLASH SAMPLED

Use Pesticides Safely

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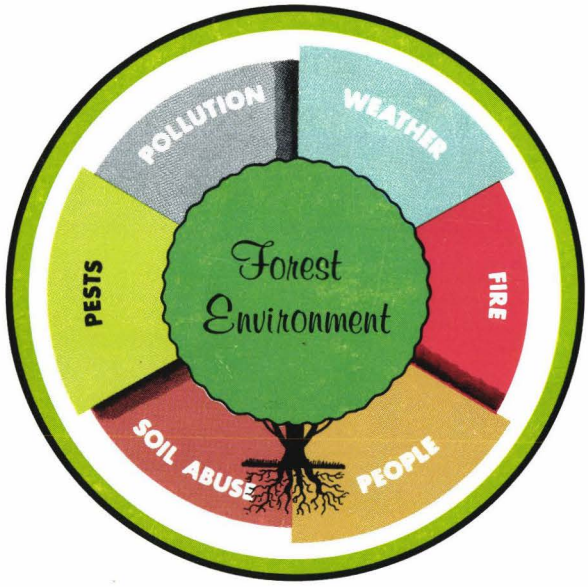

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